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INSTRUCTION REPORT K-81-6

USER'S GUIDE: COMPUTER PROGRAM FOR OPTIMUM NONLINEAR DYNAMIC DESIGN OF REINFORCED CONCRETE SLABS UNDER BLAST LOADING (CBARCS)

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March 1981

Final Report

A report under the Computer-Aided Structural Engineering (CASE) Project

Prepared for Office, Chief of Engineers, U. S. Army
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is a user's guide for CBARCS, a computer program for optimum nonlinear dynamic design of reinforced concrete slabs under blast loading. Given the explosive parameters and geometry of the slab, CBARCS computes the blast environment and the structural resistance, mass, and stiffness of the slab and solves for the dynamic response. The program contains optimization subroutines that provide for automatic optimum design of least-cost structural slabs. CBARCS will assist engineers in the design and analysis of facilities that are intended to contain the effects of accidental explosions.

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Preface

This user's guide documents a computer program called CBARCS that can be used to determine the nonlinear dynamic response of reinforced concrete slabs subjected to blast (pressure-time) loading. CBARCS is a modified version of a program called BARCS that was written by Mr. John M. Ferritto, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, Calif. The program was modified to include gas pressure loadings used by the Huntsville Division (described in HNDM-1110-1-2) and to allow it to execute in a time-sharing mode with free field input. The program is useful for initial sizing of concrete slabs, but the fine points such as diagonal steel at the supports and in plane tension forces must be considered separately in accordance with Technical Manual 5-1300. The work in modifying the program and preparing this user's guide was sponsored through funds provided to the Waterways Experiment Station (WES) by the Office, Chief of Engineers (OCE), under the Computer-Aided Structural Engineering (CASE) Project.

The program was tested and recommended for Corps of Engineers' use by the CASE Task Group on Structures Subject to Explosion:

Mr. Robert M. Wamsley, Huntsville Division (Chairman)
Mr. Dennis Bellet, Sacramento District
Mr. William Hill, Middle East Division
Mr. Byron Foster, South Atlantic Division
Mr. William Gaube, Omaha District
Dr. Paul F. Mlakar, WES
Mr. Ferritto

Major parts of this user's guide are taken directly from Mr. Ferritto's original report on BARCS (CEL Technical Note No. N-1494). Mr. Paul K. Senter, Automatic Data Processing (ADP) Center, WES, and Mr. Wamsley wrote those parts pertaining to the modifications. Dr. N. Radhakrishnan, Special Technical Assistant, ADP Center, WES, monitored the work, assisted by Mr. Senter. Mr. Donald L. Neumann was Chief of the ADP Center. Mr. Seymour Schneider, Advanced Technology Branch, Military Programs Directorate, was the OCE point of contact.

Director of WES during the period of development was COL N. P. Conover, CE. Technical Director was Mr. F. R. Brown.

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Conversion Factors, Inch-Pound to Metric (SI) Units of Measurement

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic metres
feet	0.3048	metres
inches	2.54	centimetres
pounds (force) per inch	1.75126850	newtons per centimetre
pounds (force) per square inch	6.89475789	kilopascals
pounds (mass)	0.45359237	kilograms
square feet	0.09290304	square metres

USER'S GUIDE: COMPUTER PROGRAM FOR OPTIMUM DYNAMIC DESIGN OF NONLINEAR REINFORCED CONCRETE SLABS UNDER BLAST LOADING (CBARCS)*

Background of Original Computer Program (BARCS) Development

1. The Department of Defense (DOD) has numerous facilities engaged in the production of various types of explosives and munitions used by military services. In most cases, the production of ammunition utilizes assembly line procedures. Projectiles pass through various stages of preparation: filling with explosive, fuzing, marking, and packing. Hazardous operations, such as the filling of the projectile case with an explosive in a powder form and the compaction of the powder by hydraulic press, are accomplished in protective cells that are intended to confine the effects of an accidental explosion.

2. Most of the existing production facilities were built in the 1940's. With few exceptions, the manufacturing technology and existing equipment represent the state of the art as of 1940. The production equipment was operated extensively during World War II, again during the Korean conflict, and recently during the Southeast Asia war. Much of this equipment and the housing structures have been operating beyond their designed capacities (Gill et al. 1973).

3. DOD is conducting an ammunition plant modernization program (Mendolia 1973) that is intended to greatly enhance safety in the production plants by protective construction, automated processing, and reduction of personnel involved in hazardous operations.

4. In 1969, a joint-service manual, Technical Manual 5-1300 (Departments of the Army, Navy, and Air Force 1969), was published to provide guidance to structural designers of munition plants. The

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* Three sheets entitled "Program Information" have been hand-inserted inside the front cover of this report. They present general information on the program and describe how it can be accessed. If procedures used to access this and other CORPS library programs should change, recipients of this report will be furnished a revised version of the "Program Information."

objectives of the manual were to establish design procedures and construction techniques to prevent propogation of explosions from one building, or part of a building, to another; to prevent mass detonations; and to provide protection for personnel and equipment. The manual establishes blast-load parameters for designing protective structures, provides methods for calculating the dynamic response of concrete walls, and establishes construction details for developing required strength. The design method accounts for close-in effects of a detonation with its associated high pressures and nonuniformity of loading on protective barriers. A detailed method of assessing the degree of protection afforded by a protective facility did not exist prior to publication of TM 5-1300; consequently, the manual represents a significant improvement in design methods. The simplifications made in the development of the design procedures have been presented in the manual. The analysis of a structure using the design procedure will generally result in a conservative estimate of the structure's capacity; therefore, structures designed using these procedures will generally be adequate for blast loads exceeding the assumed load conditions.

5. Even with the simplifications presented in TM 5-1300, the computational procedures are complex and time-consuming. An automated procedure was required to give structural designers the capability to perform rapid analysis of the structural safety of blast-resistant construction. The design parameters interact in a complex way since the procedure is both nonlinear and dynamic. From a design point of view, an optimization procedure was required to minimize cost and maximize safety since blast-resistant construction has been reported to cost 3 to 5 times as much as conventional construction. Thus, the first objective was to automate the analysis procedures for determining structural response of reinforced concrete slabs having a bilinear stiffness representation and subjected to blast shock and gas pressures. Concrete slabs are the basic element forming side walls, roofs, and floors of cells designed to confine the effects of accidental explosions. The second objective was to provide an optimum design procedure for laced and unlaced reinforced concrete slabs that will automatically produce a least-cost design for a given slab geometry, material properties, and explosive weight for both feasible and nonfeasible starting points.

Theoretical Development

Blast loads and structural response

6. In general, the methods used in the computer program follow those in TM 5-1300, and, as such, the accuracy of both is the same. Since these are discussed in detail in the manual and in Ferritto (1976), they will not be presented here. The solution of the dynamic response equation of motion has been found to agree very closely with the response chart of TM 5-1300. Additionally, the solution covers a wider range and thus is more accurate in the areas not defined by the response chart. When the loading is less than one hundredth of the natural period, the response is determined by impulse equilibrium. The basic dynamic model is limited to one mode of response and does not consider higher modes.

7. The ultimate moment capacity M_u of the slab is based on Equation 5-4 of TM 5-1300:

$$M_u = \frac{(A_s - A'_s)f_s}{b}\left(d - \frac{a}{2}\right) + \frac{A'_s f_s}{b}(d - d')$$

where

A'_s = area of compression reinforcement

A_s = area of tension reinforcement

f_s = design steel stress

b = width

d = distance from extreme compression fiber to centroid of tension reinforcement

a = depth of equivalent rectangular stress block

d' = distance from extreme compression fiber centroid to compression fiber

8. This equation for equal reinforcement in tension and compression reduces to

$$M_u = \frac{A'_s f_s}{b}(d - d')$$

9. The action of the concrete in compression is neglected, because crushing at high rotations is assumed to occur. This results in disengagement of the concrete cover. When support rotations are restricted by lack of lacing, this equation becomes conservative. However, the more conventional concrete analysis procedures were not included to conform with the methodology given in TM 5-1300.

10. The blast impulse computation is restricted to a geometry in which the slab height-to-length ratio is greater than 0.2. The modification made by the Naval Surface Weapons Center to the original Picatinny Arsenal program did not affect the results significantly for most cases. However, it did remove several minor problem areas, such as the location of the charge. The blast impulse has all the limitations associated with the original Picatinny programs that are caused by limitations in the test data. It assumes the charge is an equivalent sphere of TNT. Shape effects, explosive equivalence, and explosive casings are considered, but only in an empirical manner as a result of limited available data.

Structural optimization

11. The optimization problem consists of finding the least-cost structure that satisfies all the design constraints. Or, stated in optimization terms: Find $\vec{X}$ such that $M(\vec{X})$ is a minimum and

$$g_i(\vec{X}) \leq 0 \qquad i = 1, 2, N$$

where

$\vec{X}$ = vector of design variables

N = number of design constraints

g = vector of design constraints

M = objective function

Specifically for this problem, the design variables selected are areas of steel reinforcement and thickness of concrete. The design constraints are the flexural and shear limits. The objective function consists of the costs of formwork and concrete flexural and shear reinforcement.

12. <u>Fixed variables:</u>

W = explosive weight

H = wall height

EL = wall length

h = height of explosive above flood

ℓ = distance of explosive from left side of wall

R_a = distance of explosive from wall

I = reflection code

f_{dc} = ultimate dynamic concrete strength

f_{dy} = dynamic yield strenght of reinforcing steel

θ = rotations criterion

13. <u>Design parameters, X :</u>

$$X = \begin{cases} t_c = \text{concrete thickness} \\ AV = \text{area of vertical reinforcing steel} \\ AH = \text{area of horizontal reinforcing steel} \end{cases}$$

14. <u>Constraints, g(X) :</u>

$\delta(X) = \delta(\theta)$, maximum deflection

$V(X) \leq VC$ for $\theta \leq 2$ degrees, maximum shear

$t_c \geq 12$, minimum thickness

$$\left.\begin{array}{l} AV \geq 0.0025\ bd \\ AH \geq 0.0025\ bd \end{array}\right\} \text{minimum steel reinforcement}$$

15. The methodology selected (Fox 1971, Advisory Group for Aerospace Research and Development) uses the unconstrained minimization approach. The problem is converted to an unconstrained minimization by constructing a function ϕ of the general form

$$\phi(\vec{X}, r) = M(\vec{X}) + P[g_1(\vec{X}), \ldots, g_n(\vec{X}), r]$$

For this problem, the interior penalty function technique was selected. This methodology is suitable when gradients are not available, and, because the method uses the feasible region, a useable solutions always results. The objective function is augmented with a penalty term that

is small at points away from the constraints in the feasible region, but increases rapidly as the constraints are approached. The form is as follows:

$$\phi(\vec{X}, r) = M(\vec{X}) - r \sum_{j=1}^{N} \frac{1}{g_j(\vec{X})}$$

where M is to be minimized over all $\vec{X}$ satisfying $g(\vec{X}) \leq 0$, $j = 2 \ldots N$. Note that if r is positive, the, since at any interior point all of the terms in the sum are negative, the effect is to add a positive penalty to $M(\vec{X})$. As the boundary is approached, some $g(\vec{X})$ will approach zero, and the penalty will increase rapidly. The parameter r will be made successively smaller in order to obtain the constrained minimum of M.

16. Objective function F:

$$\text{Cost} = F = H \cdot EL \cdot t_c \cdot C_c$$

$$+ (AV + AH)(EL \cdot H)C_s + (A_s)(EL \cdot H)C_L$$

where

C_c = cost of concrete, dollars/ft^3
C_s = cost of horizontal and vertical reinforcement, dollars/in.^{3}
C_L = cost of lacing reinforcement, dollars/in.^{3}
A_s = area of lacing reinforcement, dollars/in.^{3}

$$\phi = F + r \sum_{j=1}^{N} \left[\frac{1}{g_j(\vec{X})} \right]$$

where r is the penalty parameter.

17. The program requires a starting point in the feasible region before optimization can proceed. This is accomplished automatically by the program incrementing the design variables until a feasible point is reached.

18. An algorithm which comprises the steps most commonly used is as follows:

- a. Given a starting point X_o satisfying all $g_j(\vec{X}) \leq 0$ and an initial value for r, minimize ϕ to obtain X_{min}.
- b. Check for convergence of X_{min} to the optimum.
- c. If the convergence criterion is not satisfied, reduce r by $r \leftarrow rc$, where $c < 1$.
- d. Compute a new starting point for the minimization, initialize the minimization algorithm, and repeat from step a.

19. The logic diagram for the interior penalty functions technique is shown in Figure 1.

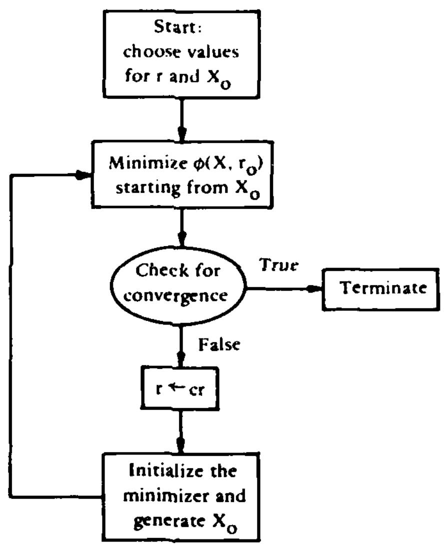


Figure 1. Logic diagram for interior penalty function technique

20. The minimization for $\phi(X, r)$ shown in Figure 1 is accomplished by a method developed by Powell using conjugate directions (Fox 1971, Advisory Group for Aerospace Research and Development. Powell's method can be understood as follows: Given that the function has been minimized once in each of the coordinate directions and then in the associated pattern direction. Discard one of the coordinate directions in favor of the pattern direction for inclusion in the next M

minimizations, since this is likely to be a better direction than the discarded coordinate direction. After the next cycle of minimizations, generate a new pattern direction, and again replace one of the coordinate directions. This process is illustrated in Figure 2.

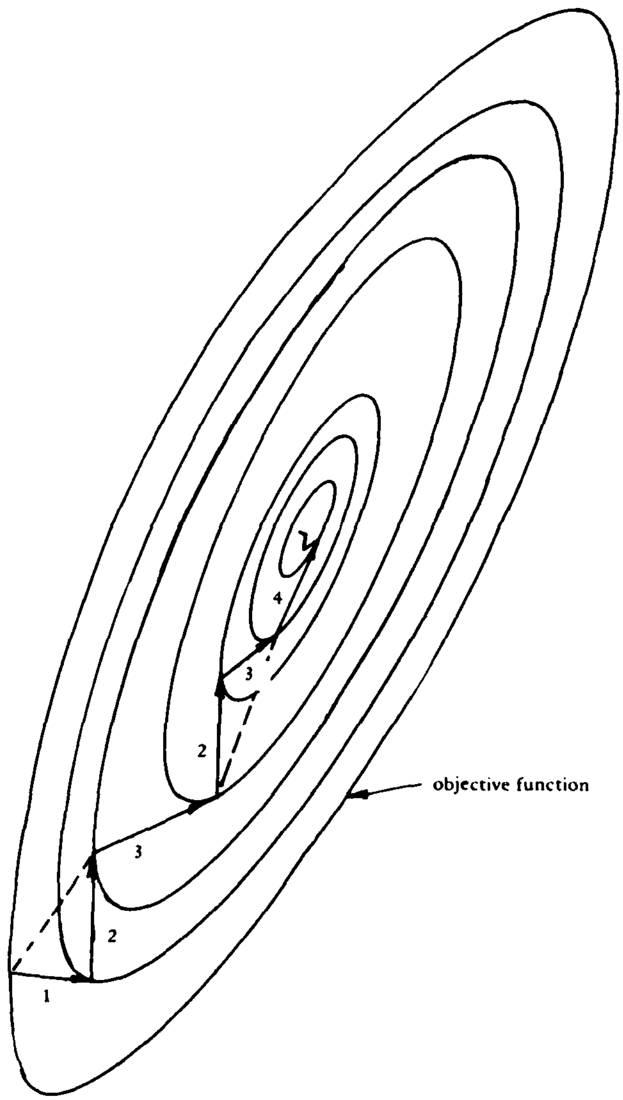


Figure 2. Step process, Powell method

21. Figure 3 is a logic diagram for the unconstrained minimization algorithm. The pattern move is constructed in block A, then used

for a minimization step (blocks B and C), and then stored in S_n (block D) as all of the directions are up-numbered and S_1 is discarded. The direction S_n will then be used for a minimizing step just before the construction of the next pattern direction. Consequently, in the second cycle, both X and Y in block A are points that are minima along S_n, the last pattern direction. This sequence will impart special properties to $S_{n+1} = X - Y$ that are the source of the rapid convergence of the method.

22. Figure 3 shows a block requiring a one-dimensional minimization of $\alpha*$ of the function $\phi(\vec{X} + \alpha S_q)$. The one-dimensional minimizationuses a four-point cubic interpolation. It finds the minimum along

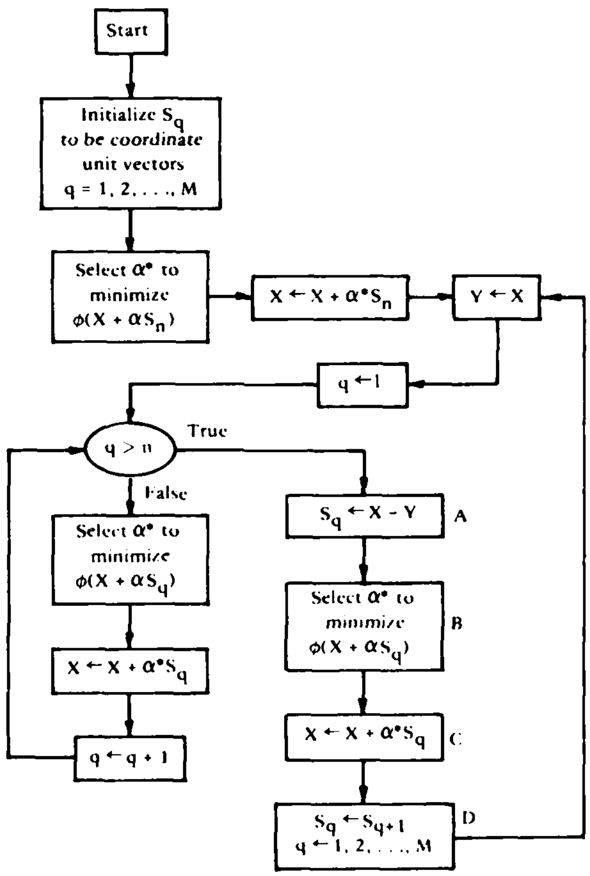


Figure 3. Logic diagram for minimization of $\phi(\vec{X})$

the direction S_q , where X is the coordinate of the previous minimum. By trial and error, it finds three points with the middle one less than the other two. It makes a quadratic interpolation, and then a cubic interpolation. If the actual function evaluated at the new interpolated point is not sufficiently close to that of the preceding point or if it is not sufficiently close to the interpolated function, then another cubic interpolation is made. The logic for this algorithm is shown in Figure 4.

Discussion

23. The objective function is linearly dependent on the design variables; however, the constraints are both linearly and nonlinealy related to the design variables. The minimum area of steel is a linear constraint. Figures 5 and 6 show the shear stress and the deflection as being nonlinearly related to the thickness of the concrete. Note that the shear stress is almost linear and is constant (independent of thickness). Figure 7 shows the useable region bounded by flexure, shear, and minimum steel constraints. The optimum least-cost solution is shown. This specific example solution considers an unlaced section; thus, the maximum shear constraint is active. Laced sections eliminate the shear constraint. If the number of sides supported were increased from $N = 2$ to $N = 3$, the design space would change as shown in Figure 8. There are two regions that are useable areas. Obviously, the lower one offers the least cost and, therefore, is more desirable.

24. There is clearly a complex interaction of constraints. Unfortunately, the optimum solution found by the program depends on the starting point selected. The program converges on the closest relative optimum. Several alternative starting points should be used to verify a questionable optimum. Revising the design parameters could possibly shift the constraints such that only one useable solution would appear. However, a slight increase in shear stress (10 percent) can significantly reduce cost by allowing the near-optimum nonfeasible solution to be accepted.

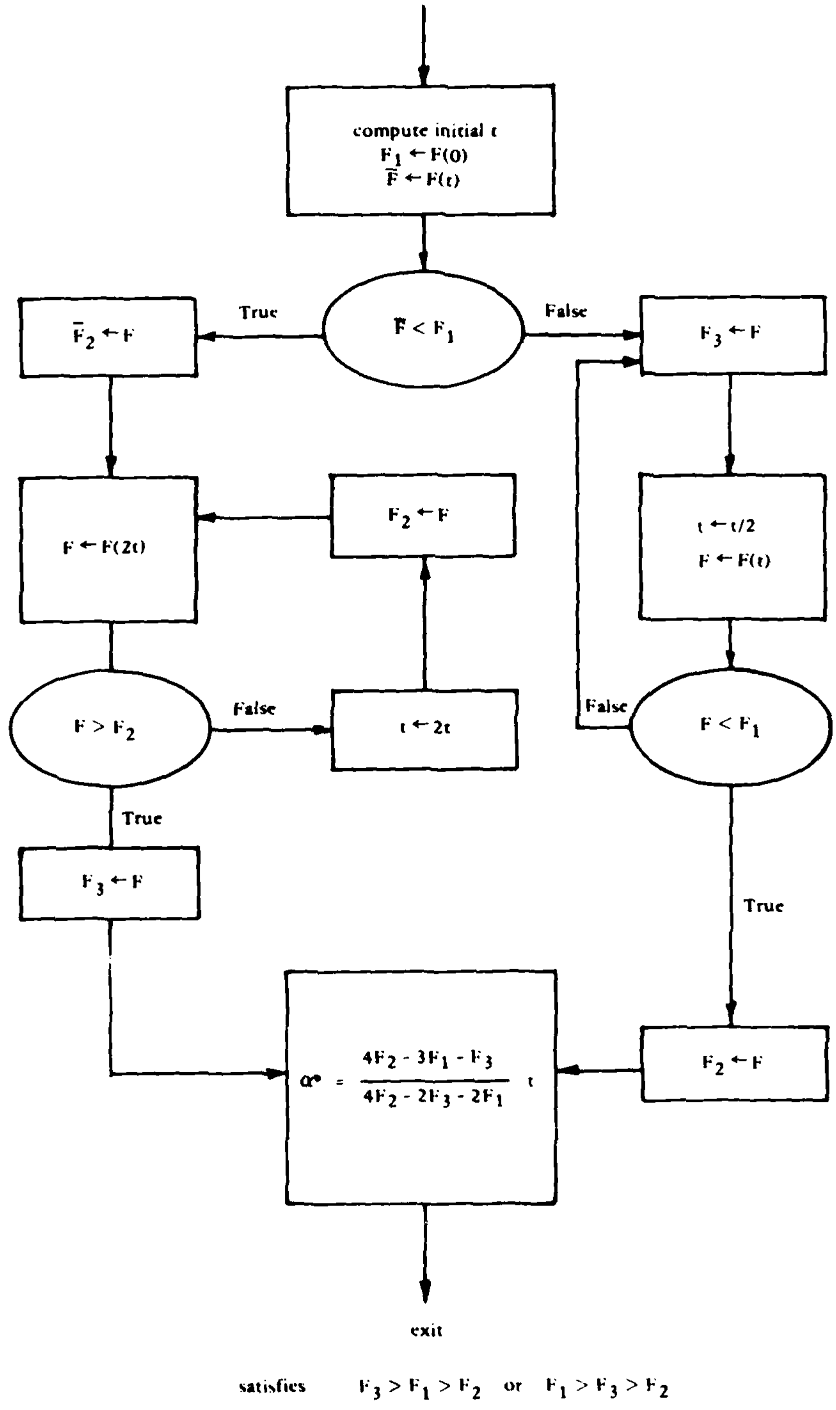


Figure 4. One-dimensional minimization algorithm

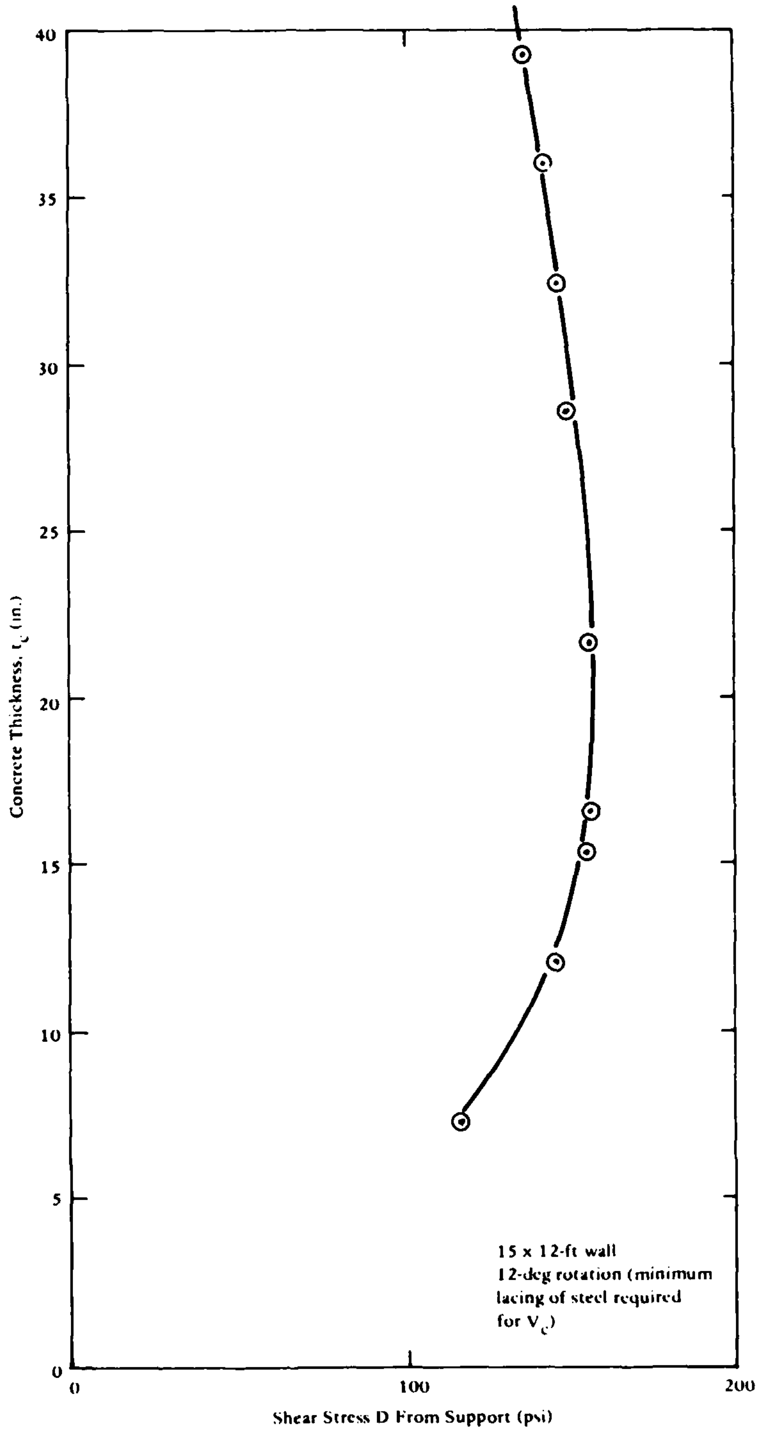
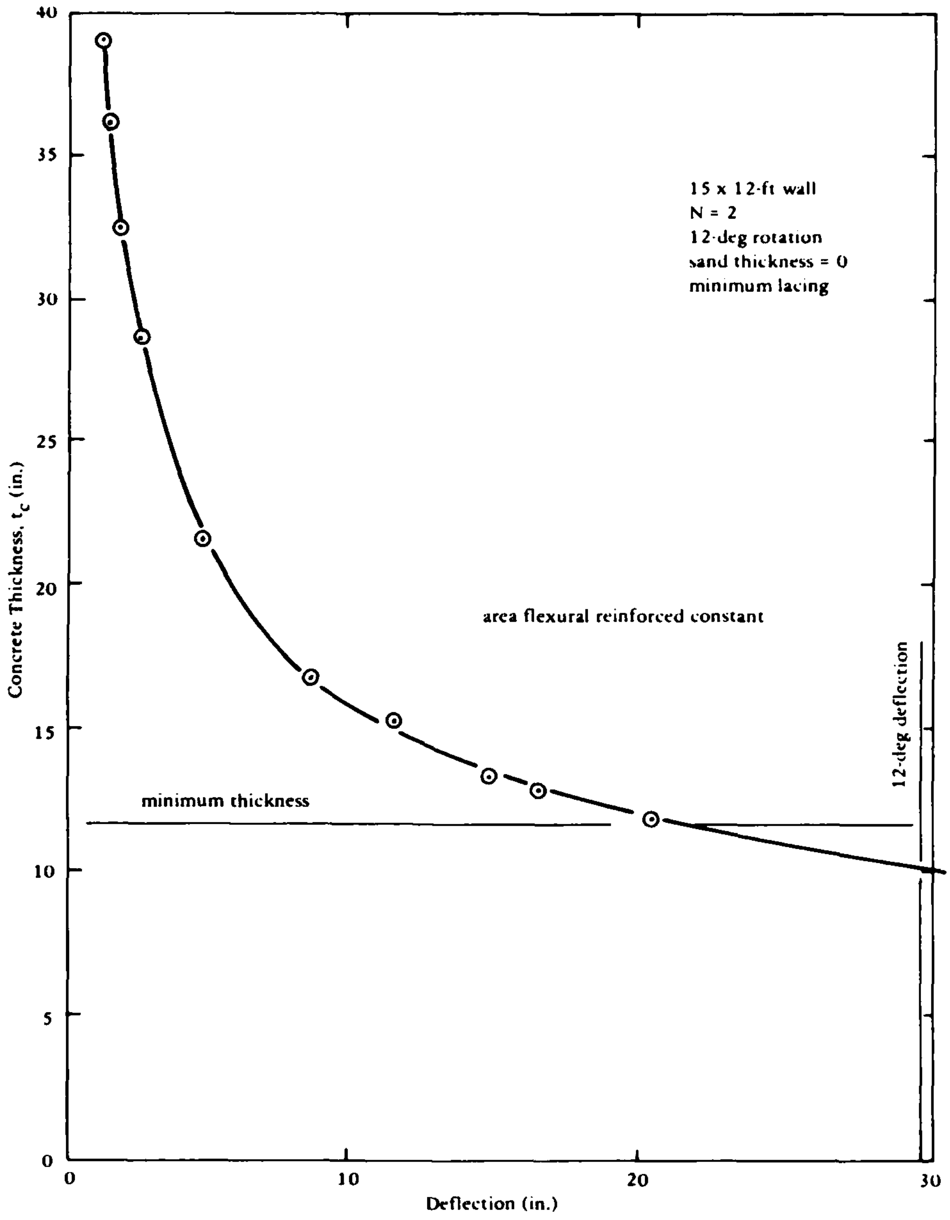


Figure 5. Shear stress as a function of thickness



AS constant

Figure 6. Deflection as a function of thickness

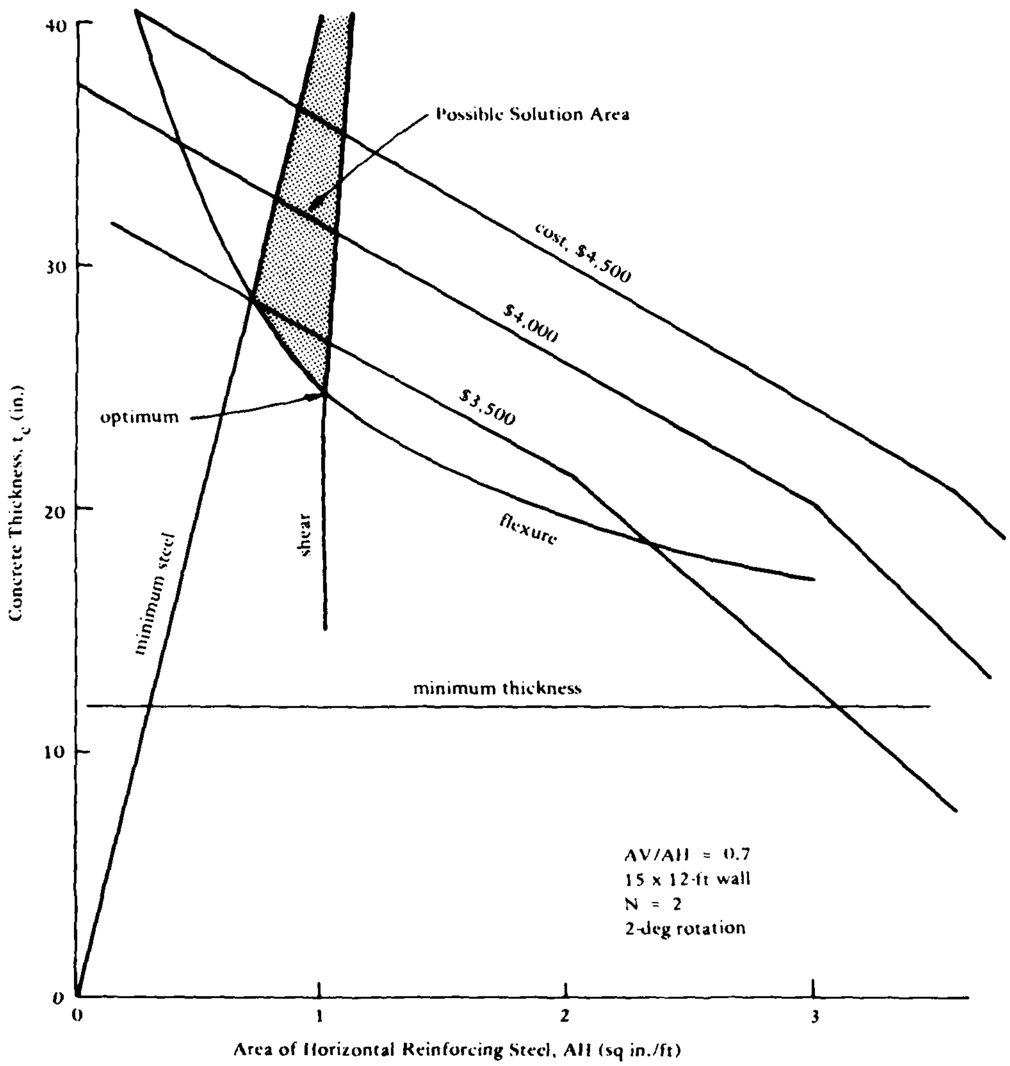


Figure 7. Design space, N = 2

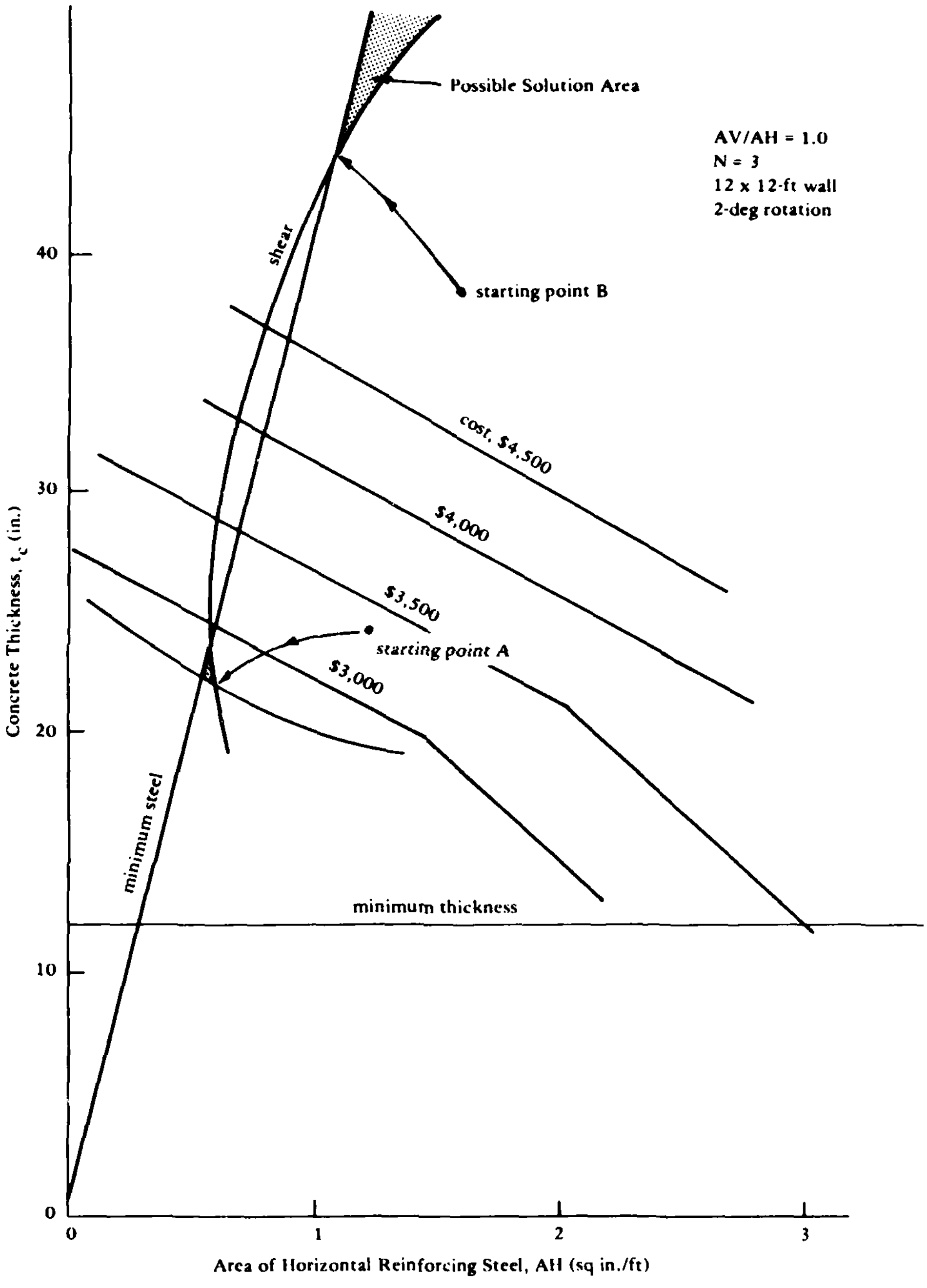


Figure 8. Design space, N = 3

25. The dual-space problem of finding a useable solution is limited to unlaced concrete slabs only because lacing eliminates the shear constraint. Nonautomated design for these conditions is almost impossible when one considers the complexity of the design space and the large number of iterations required when an initial solution is not feasible.

26. Cost data used in the program can be selected by the user. However, the data used herein are based on work by Picatinny Arsenal on contract with Ammann and Whitney (Dede et al. 1972). Table 1 shows a comparison of unlaced and laced concrete walls with and without sand. The example considers a 15-ft-high* by 12-ft-wide wall subjected to a 200-psi, 10-msecond triangular loading function. In all cases the laced concrete (12-degree rotation) is less expensive than unlaced (2-degree rotation) designs. The costs for sand-concrete composite construction are for only the front wall. When the rear wall is included, the costs are almost double, thereby making this form of construction unsuitable for relatively low-pressure loadings. It should be pointed out that, for the $N = 3$ and 4 conditions, the optimum design selected is actually a near-ptimum with the shear capacity slightly exceeded as shown in Figure 9.

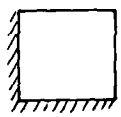
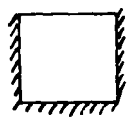
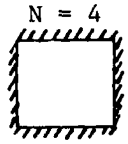
27. The program contains an option to analyze wall with openings. During many analyses, it was noted that blast doors with resistances much higher than those of the walls transfer significant reactions to the walls such that the walls are incapable of accepting these and fail. Computational problems arise in the program when this happens in that uield regions cannot be brought into equilibrium by yield analysis methods. To avoid termination of the solution at this point, the door resistance is reduced automatically by a factor of 2 to reduce the reaction. This usually allows for a successful termination. Unfortunately, this destroys the original starting point for optimization, and creates problems when a nonfeasible low-cost solution is lost and cannot be used to provide direction. It is, therefore, not possible to perform optimization solutions of walls with openings. Generally, it

* A table of factors for converting inch-pound units of measurement used in this report to metric (SI) units is presented on page 3.

has been found that compatible designs occur when the door is designed to have approximately the same resistance as the wall.

Table 1

Comparison of Optimum Solutions
For a 15-ft-high by 12-ft-long Wall
Subjected to a 200-psi, 10-msecond
Angular Loading Function

N Side	Theta degrees	Sand in.	Cost dollars
N = 2 	2	0	3,290
	12	0	2,289
	2	24	2,209*
	12	24	1,856*
N = 3 	2	0	2,753*
	12	0	2,019
	2	24	1,944*,**
	12	24	1,943*
N = 4 	2	0	2,001*
	12	0	1,958
	2	24	2,001*,**
	12	24	1,943*

* One wall only in composite construction.

** Shear capacity exceeded.

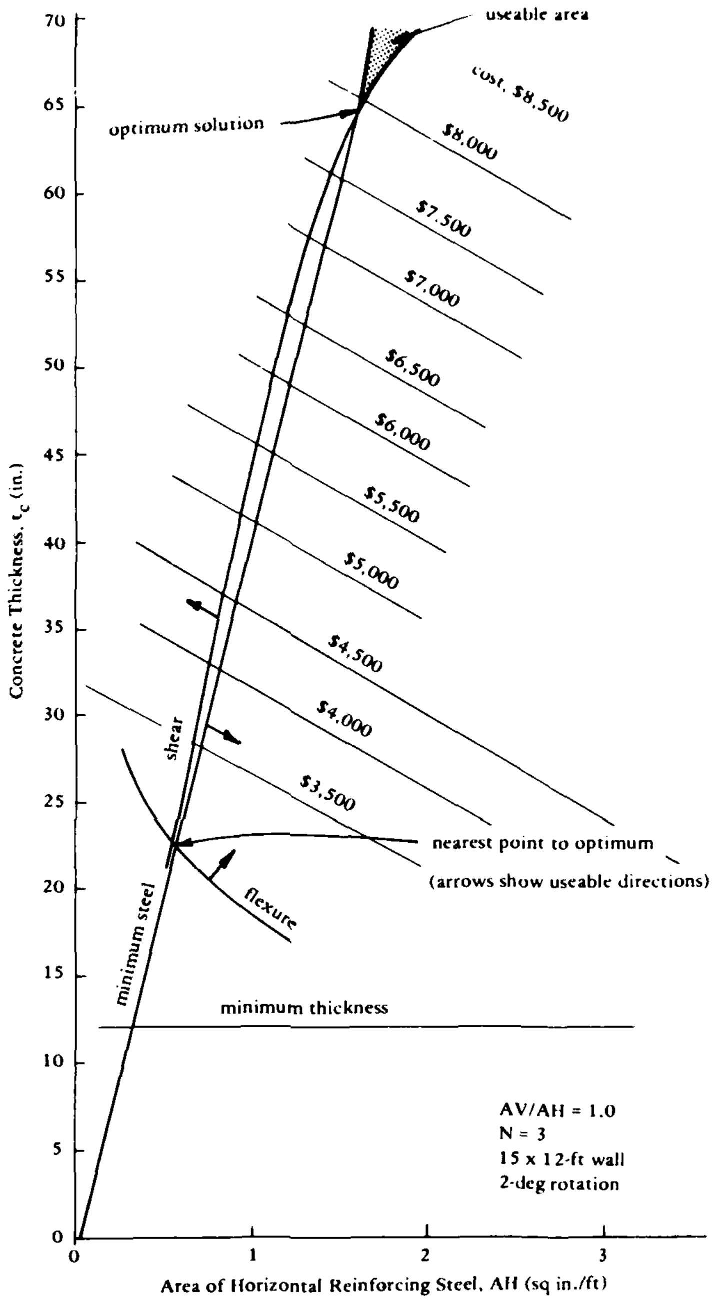


Figure 9. Revised design space, N = 3

The Computer Program

28. The program is composed of four areas:

a. Blast-load determination.

b. Structural analysis parameters.

c. Dynamic response.

d. Optimization.

29. The blast-load determination is accomplished by subroutines BLA, PIC, SGRID, HBA, RATIO, GRID, GAS INTERP, EQUIV, HEDATA, ARDC, SHOCK, and TNT. The subroutines read the explosive weight and type and cell geometry, and then compute the equivalent spherical weight of TNT and the equivalent pressure loading using the geometry of the wall and charge location. Both the shock pressure and its duration and the gas pressure and its duration are calculated. Using the duration and pressure data for both shock and gas, the program computes an equivalent triangular pressure loading for each part and adds both together to produce the resultant shown in Figure 10. The total impulse is then determined.

30. The structural analysis is accomplished by subroutines SSTIFF, LACE, DOOR 1, DOOR 2, DOOR 3, DOOR 4, and DOOR 5. These routines compute the stiffness, resistance, and equivalent mass of the slab using input material properties. Both flexure and shear are considered. Openings (doors and windows) in walls are allowed.

31. The dynamic response calculation is accomplished in subroutine RESP. The program determines the response of the slab modeled as an equivalent dynamic single-degree-of-freedom system with bilinear stiffness and pressure loading as shown in Figure 10. The solution technique is based on a Newmark iteration method.

32. When a thickness of sand is specified for composite construction (i.e., two slabs with sandfill), the program computes the impulse capacity of the first slab using half the mass of the sand as acting with the wall. Figures 6-38 and 6-39 of TM 5-1300 give the attenuation of the blast wave on the sand for evaluation of the impulse capacity of the second wall. The optimization of an initial design is accomplished in

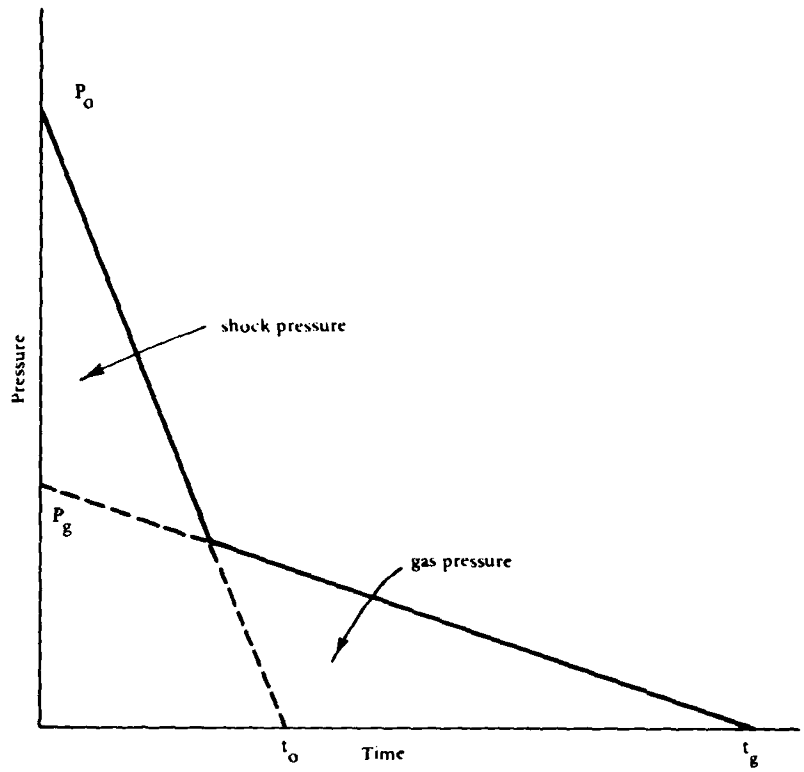


Figure 10. Equivalent pressure loading

subroutines OPT, MINIMZ, PMINZ, DMINZ, GETE, SUMRY, TLEFT, and GCOMP. The methodology used is that of a penalty function with individual minimization sequences being accomplished by the Powell method.

Program input

33. The following sections describe the data input phase of CBARCS and the various options available. A data input guide was prepared to aid the user in data preparation. A copy of this guide with appropriate entries is presented later with each example problem. Also, a blank copy of the guide is presented at the back of this report. Illustrative results are presented for the following example problems.

- a. Analyze back wall for Type I cross section.
- b. Analyze left side wall for same geometry as given in a.
- c. Perform optimization and use impulse grid.
- d. Use same wall geometry as in c but with a roof.
- e. Use same condition as in a but increase wall height and use a door.

34. Defining a problem involves specification of 8 basic data groups composed of about 58 variables. The program can be run by making use of an existing data file having sequence numbers at the start of each line. As an alternative mode of input, an interactive phase is also provided which assists the user in defining data for a particular problem. All data are entered in free field format with commas or blanks used to separate the successive numbers. All values can be input with or without decimal points (for instance, FLAG1 = 1 can be input either as 1. or as 1). If the user so desires, data input interactively can be saved into a permanent file with line numbers. The output from a problem can be written to the terminal or into a permanent file to be either scanned with an editor or sent to a line printer.

35. The user should be aware that data saved in a file may not coincide exactly with the values input interactively. The data are written to a file using field widths adequate for practical situations. For instance, most variables are written using two digits past the decimal point. In the event that greater accuracy is needed in the recorded data, the data file can be edited accordingly.

36. The different data groups with names of the variables for each one as used in the program are as follows:

a. Data group 1--Cost Data (CYD, CCS, CCSH, CI, SDIF):

- CYD - Cost of concrete, $\$/yd^3$ (default = 50.0)
- CCS - Cost of flexural steel, \$/lb (default = 0.2)
- CCSH - Cost of lacing, \$/lb (default = 0.325)
- CI - Inflation factor (default = 1.5)
- SDIF - Dynamic increase factor for flexural steel

b. Data group 2--Heading (HDG):

- HDG - Alphanumeric heading for problem identification 68 characters maximum

c. Data group 3--Program Control (FLAG1, FLAG2, FLAG3, FLAG4, FLAG5, PC):

- FLAG1 - Set = 1 for optimization; otherwise = 0
- FLAG2 - Set = 0 to calculate gas pressure; set = 1 to input gas pressure
- FLAG3 - Set = 0 for reinforcing area, $in.^2/ft$; set = 1 for reinforcing diameter and spacing, in.

FLAG4 - Set = 1 for impulse grid; otherwise = 0

FLAG5 - Set = 1 for door/window reaction present; otherwise = 0

PC - Set = 0 for standard printout
= 1 for print response time-history
= 2 for print door/window equilibrium iteractions

d. Data group 4--Load Parameters (WLB, ANUM, RLOD, CASE, APAMB, TAMB, ALTKFT, PERCE):

WLB - Weight of actual explosive including safety factor, lb

ANUM - Explosive number used to compute explosive equivalence (see Table 2 for list of explosives)

RLOD - Explosive length to diameter ratio (default = 1)

CASE - Projectile case weight to explosive weight ratio (use 0 for conservative analysis)

APAMB - Ambient air pressure, psia (default = 14.69)

TAMB - Ambient temperature, °C (default = 20°C)

ALTKFT - Altitude, 10^3 ft (when APAMB and TAMB not specified)

PERCE - Effective impulse fraction for composite construction (default = 1.0)

e. Data group 5--Geometry:

(1) When gas pressure is calculated (FLAG2 = 0) input (RR, H, EL, HLIT, ELLIT, AV, AC, ICODE(i), where i = 1, 2, 3, or 4):

RR - Distance from charge to wall, ft

H - Wall height, ft

EL - Wall length, ft

HLIT - Height of charge, ft

ELLIT - Distance of charge to left boundary, ft

AV - Cell volume for gas pressure, ft^3

AC* - Cell vent area for gas pressure, ft^2

ICODE(1) - Set = 1 for floor reflection; otherwise set = 0

ICODE(2) - Set = 1 for roof reflection; otherwise set = 0

---

* CBARCS will not solve for gas pressure if vent area = 0.

ICODE(3) - Set = 1 for left wall reflection; otherwise set = 0

ICODE(4) - Set = 1 for right wall reflection; otherwise set = 0

(2) <u>When gas pressure is input (FLAG2 = 1) input (TOTIM, H, EL, FPRES, TO, PG, TG, ICODE(i), where i = 1, 2, 3, or 4):</u>

TOTIM - Total impulse, psi-msec

H - Wall height, ft

EL - Wall length, ft

FPRES - Peak pressure, psi

TO - Duration of peak pressure, msec

PG - Gas pressure, psi

TG - Gas pressure duration, msec

ICODE(1) - Set = 1 for floor reflection; otherwise set = 0

ICODE(2) - Set = 1 for roof reflection; otherwise set = 0

ICODE(3) - Set = 1 for left wall reflection; otherwise set = 0

ICODE(4) - Set = 1 for right wall reflection; otherwise set = 0

<u>f</u>. <u>Data group 6--Strength Parameters (FC, FST, TC, THETA, SN, TSAND, BL, SL):</u>

FC - Concrete dynamic strength, psi

FST - Steel static design strength, psi

TC - Overall thickness of concrete, in. (12 in. minimum)

THETA - Allowable rotation, degrees

SN - Support code (see Figure 11a):

= 1, bottom fixed
= 2, bottom and 1 side fixed
= 3, bottom and 2 sides fixed
= 4, 4 sides fixed
= 5, beam simple supports top and bottom
= 6, beam fixed top and bottom
= 7, beam, simple support top, fixed bottom

TSAND - Sand thickness, ft (usually = 0)

BL - Lacing spacing, in. (transverse direction)

SL - Lacing spacing, in. (peak to valley direction)

<u>g</u>. <u>Data group 7--Reinforcement:</u>

(1) When reinforcement area is specified (FLAG3 = 0), input ASVT, ASVB, ASHT, ASHB, DVT, DVB, DHT, DHB:

ASVT - Area vertical steel blast side, $in.^2/ft$

ASVB - Area vertical steel opposite side, $in.^2/ft$

ASHT - Area horizontal steel blast side, $in.^2/ft$

ASHB - Area horizontal steel opposite side, $in.^2/ft$

DVT - Depth to center of vertical steel blast side, in.

DVB - Depth to center of vertical steel opposite side, in.

DHT - Depth to center of horizontal steel blast side, in.

DHB - Depth to center of horizontal steel opposite side, in.

(2) When reinforcement diameter is specified (FLAG3 = 1), input BAR1, BAR2, BAR3, BAR4, SP1, SP2, SP3, SP4, DVT, DVB, DHT, DHB:

BAR1 - Bar size vertical blast side

BAR2 - Bar size vertical opposite side

BAR3 - Bar size horizontal blast side

BAR4 - Bar side horizontal opposite side

SP1 - Bar spacing vertical blast side, in.

SP2 - Bar spacing vertical opposite side, in.

SP3 - Bar spacing horizontal blast side, in.

SP4 - Bar spacing horizontal opposite side, in.

DVT, DVB, DHT, and DHB are the same as defined above in subparagraph 36g(1).

(All depths are measured in inches from outer concrete surface to center of reinforcement bar.)

h. Data group 8--Door or Window Parameters (see Figure 11b) input if FLAG5 = 1 (H2, WT, B, REA, RD1, H1):

H2 - Door or window height, ft

WT - Door or window width, ft

B - Distance from left side to door or window, ft

REA - Door or window reaction, lb/in. (3 sides supported)

RD1 - Resistance for calculating door or window reaction, psi (3 sides supported)

H1 - Distance to floor, ft (for window only)

Table 2

List of Explosives

Explosive Number	Explosive Name and Composition
1	TNT
2	TNETB
3	EXPLOSIVE D
4	PENTOLITE (PETN/TNT 50/50)
5	PICRATOL (EXPLOSIVE D/TNT 52/48)
6	CYCLOTOL (RDX/TNT 70/30)
7	COMP B (RDX/TNT/WAX 59.4/39.6/1.0)
8	RDX/WAX (98/2)
9	COMP A-3 (RDX/WAX 91/9)
10	TNETB/AL (90/10)
11	TNETB/AL (78/22)
12	TNETB/AL (72/28)
13	TNETB/AL (65/34)
14	TRITONAL (TNT/AL80/70)
15	RDX/AL/WAX (88/10/2)
16	RDX/AL/WAX (89/20/2)
17	RDX/AL/WAX (74/21/5)
18	RDX/AL/WAX (74/22/4)
19	RDX/AL/WAX (62/33/5)
20	TORPEX II (RDX/TNT/AL 42/40/18)
21	H6 (RDX/TNT/AL/WAX 45/29/21/5)
22	HBX-1 (RDX/TNT/AL/WAX 40/38/16/5)
23	HBX-3 (RDX/TNT/AL/WAX 31/29/35/5)
24	TNETB/RDX/AL 39/26/35)
25	ALUMINUM
26	WAX
27	RDX
28	PETN
29	TETRYL

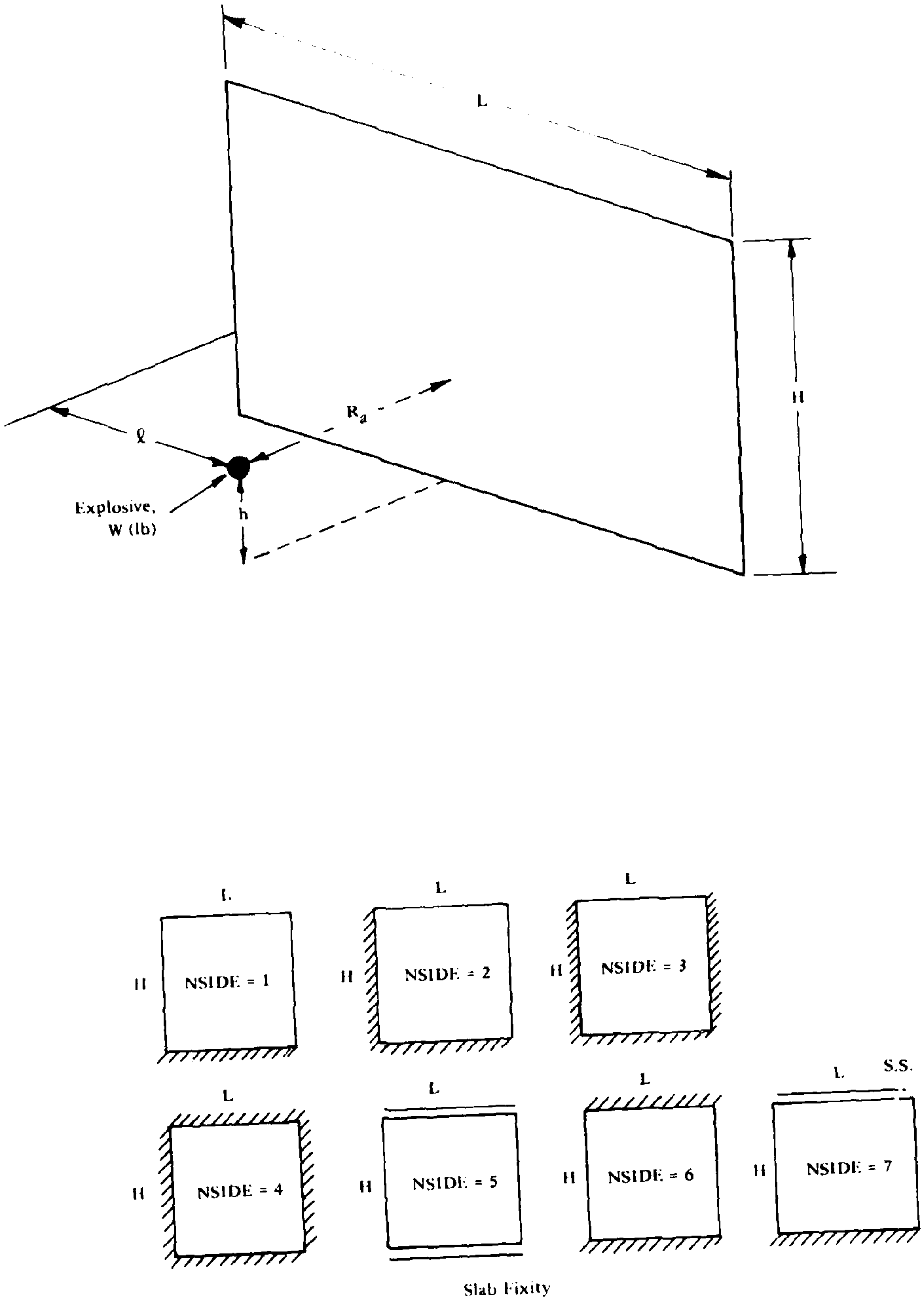
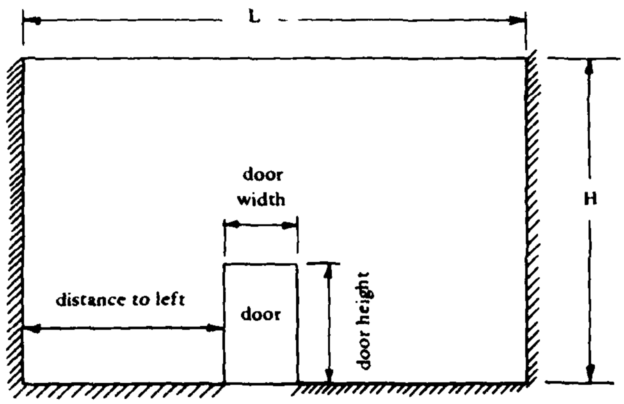
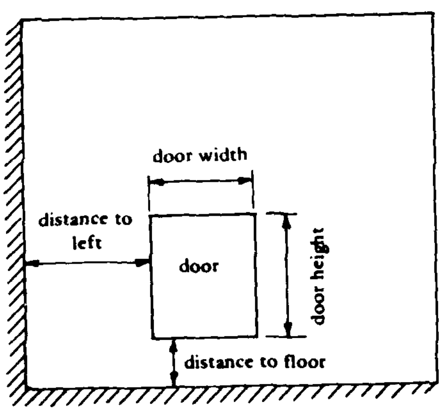


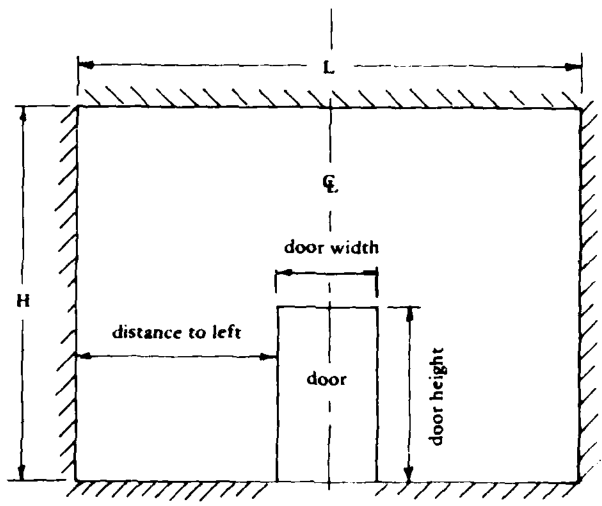
Figure 11a. Wall geometry



Wall three sides supported with door.



Two sides supported with opening.



*Note opening must be in center of wall.

Wall four sides supported with opening.

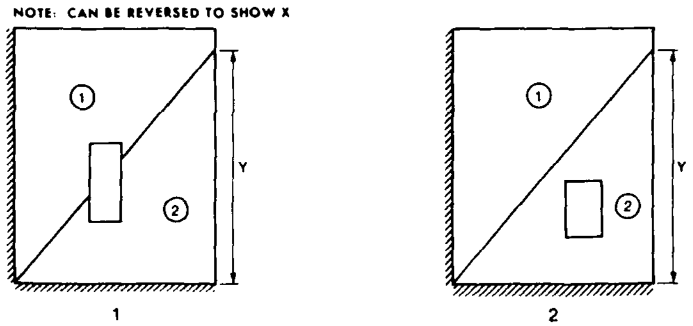
Figure 11b. Wall geometry with opening for door

Program output

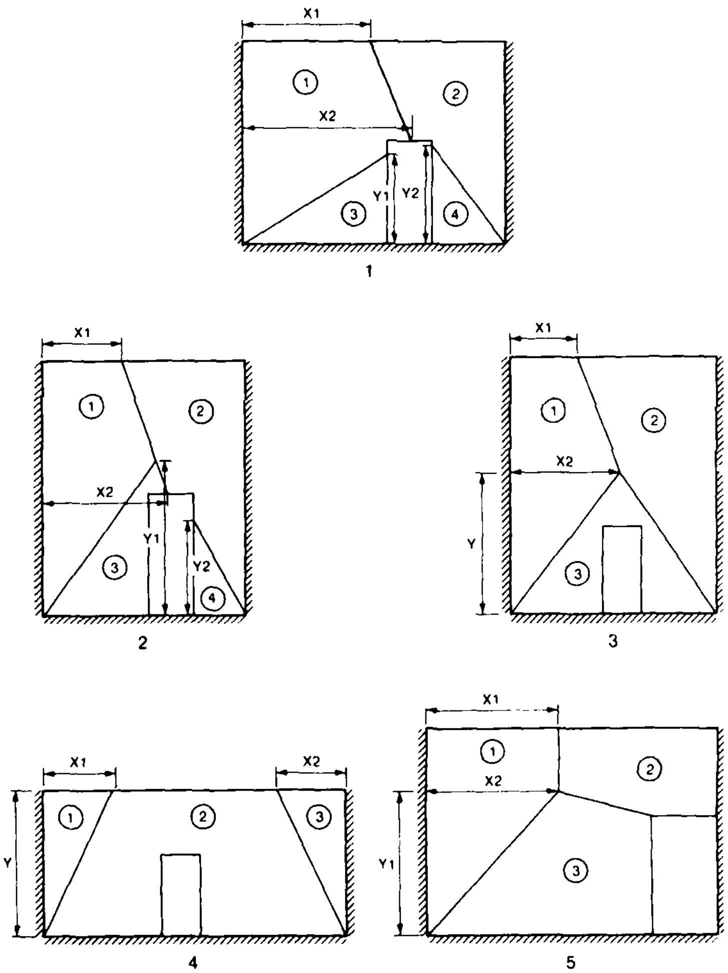
37. Sketches of yield lines which are possible and considered by CBARCS are shown in Figure 12. It may be helpful to refer to these when the door or window option is used.

Example problems

38. Five example problems are presented on pages 34-74. In example problems 1 and 2A, data were entered interactively. In problems 2B-5, data were entered from a data file.

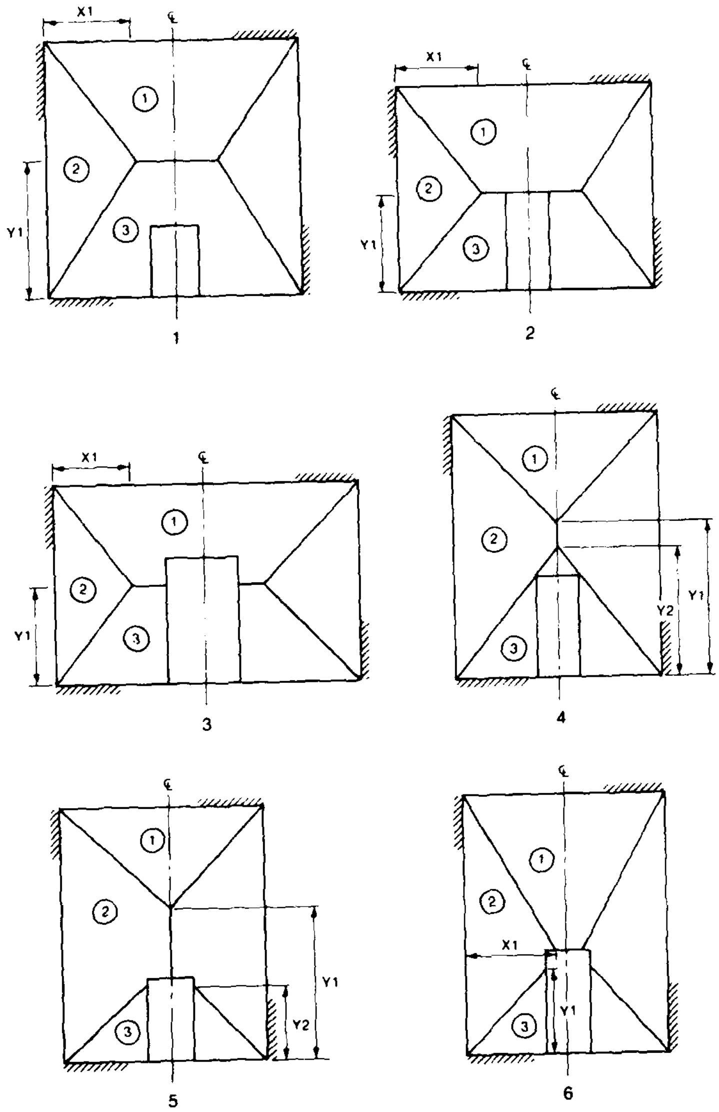


a. Two sides supported



b. Three sides supported

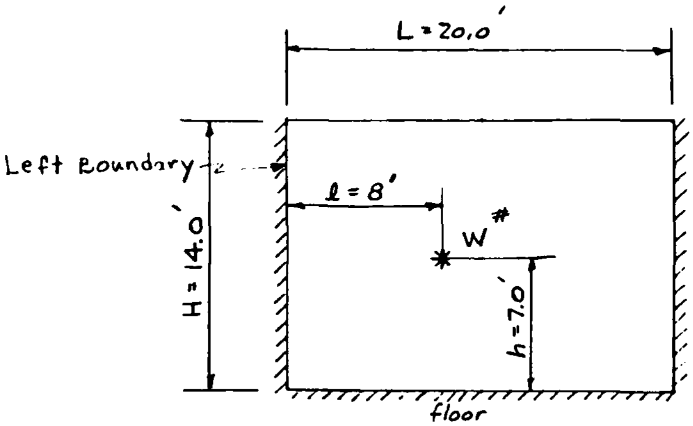
Figure 12. Sketches of yield lines which are possible with and considered by CBARCS (sheet 1 of 2)



c. Four sides supported

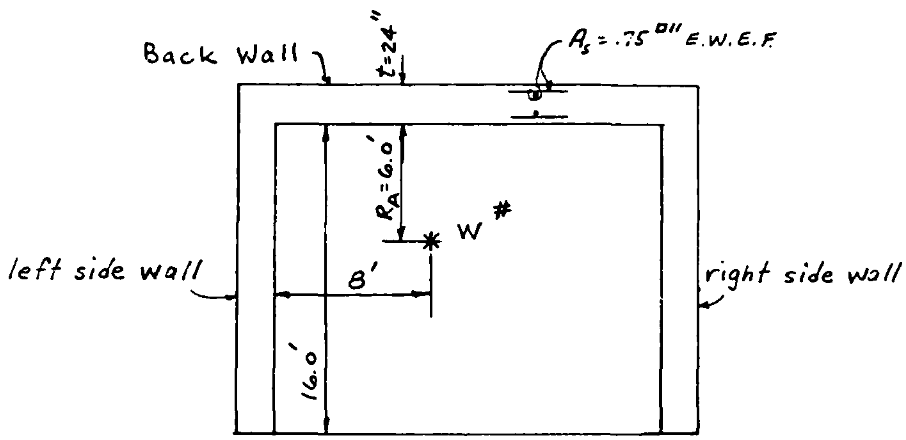
Figure 12. (sheet 2 of 2)

SUBJECT	COMPUTED BY	DATE
EXAMPLE PROBLEM 1	CHECKED BY	DATE



BACK WALL

3 SIDES FIXED
(NSIDE = 3)



PLAN

GIVEN: GEOMETRY, AS SHOWN

CHARGE W_T = 100 # TNT

$W \overset{F.S.}{=} 1.2 \times 100 = 120$ # TNT

SUBJECT	COMPUTED BY	DATE
EXAMPLE PROBLEM 1	CHECKED BY	DATE

GIVEN: (Cont'd from page 1)

TYPE I cross-section (Allowable support rotation = 2°)

f'_c = 3,000 psi

f_s = 60,000 psi (see TM for definition)

Dynamic increase factors:

Concrete compression - 1.25
" diag. tension - 1.00
" direct shear - 1.10

Reinforcing steel
bending - 1.20 {1.10 = default}
shear - 1.00 {Programmed}

Concrete cover to center of rebars:

Horizontal bars - 2"

Vertical bars - 3"

$\rho(min) = .25\%$

$A_s(min.) = .0025\,bd = .0025(12)(22) = 0.66$ $\square$"/ft.

REQUIRED: ANALYZE BACK WALL SHOWN ON PAGE 1

PARAMETERS: $R_A = 6.0'$, $H = 14.0'$, $L = 20.0'$, $h = 7.0'$, $\ell = 8.0'$

SUBJECT	COMPUTED BY	DATE
EXAMPLE PROBLEM 1	CHECKED BY	DATE

BUILD AN INPUT DATA FILE (SEE INPUT DATA FORM)

FILE NAME : BDATA1

LINE 1 0, 0, 0, 0, 1.2 Note! Cost data is needed only when performing a design optimization

LINE 2 EXAMPLE PROBLEM 1

LINE 3 0, 0, 0, 0, 0, 1

LINE 4 120, 1, 0, 0, 0, 0, 0, 0 Note! Program has built-in default values

LINE 5 6, 14, 20, 7, 8, 0, 0, 1, 0, 1, 1

LINE 6 3750, 60000, 24, 2, 3, 0, 0, 0

LINE 7 0.75, .75, .75, .75, 3, 3, 2, 2

File name: BDATA1

		CYD $/yd^3$	CCS \$/lb	CCSH \$/lb	CI	SDIF			
		(50.0)	(0.2)	(0.325)	(1.5)	(1.1)	(Default Values)		
	Line 1	0	0	0	0	1.2			
		HEADING							
	Line 2	EXAMPLE PROBLEM 1							
		FLAG1	FLAG2	FLAG3	FLAG4	FLAG5	PC		
		Optimize 0 - No 1 - Yes	Input Gas Pressure 0 - Calculate 1 - Input	Reinforcing 0 - AS 1 - D	Impulse Grid 0 - No 1 - Yes	Door Opening 0 - No 1 - Yes	0 - Standard printout 1 - Print response time history		
	Line 3	0	0	0	0	0	1		
		WLB lb	ANUM	RLOD	CASE	APAMB, psia (Default = 14.69)	TAMB, °C (Default = 20)	ALTKFT 10^3 ft	PERCE (Default = 1.0)
	Line 4	120	1	0	0	0	0	0	0
		RR ft	H ft	EL ft	HLIT ft	ELLIT ft	AV ft^3	AC ft^2	ICODE F R L R
If FLAG2 = 0,	Line 5A	6	14	20	7	8	0	0	1 0 1 1
		TOTIM psi-msec	H ft	EL ft	FPRES psi	TO msec	PC psi	TG msec	ICODE F R L R
If FLAG2 = 1,	Line 5B								
		FC psi	FST psi	TC in.	THETA degrees	SN	TSAND ft	BL in.	SL in.
	Line 6	3750	60000	24	2	3	0	0	0
		ASVT $in.^2/ft$	ASVB $in.^2/ft$	ASHT $in.^2/ft$	ASHB $in.^2/ft$	DVT in.	DVB in.	DHT in.	DHB in.
If FLAG3 = 0,	Line 7A	0.75	0.75	0.75	0.75	3	3	2	2
		BAR1	BAR2	BAR3	BAR4	SP1 in.	SP2 in.	SP3 in.	SP4 in.
If FLAG3 = 1,	Line 7B								
		DVT in.	DVB in.	DHT in.	DHB in.				
If FLAG3 = 1,	Line 7B (Continued)								
		H2 ft	WT ft	B ft	REA lb/in.	RD1 psi	H1 ft		
If FLAG5 = 1,	Line 8								

```
C>OLD,CBARCS
C>CBARCS

 INPUT NAME OF DATA FILE IN 7 CHARACTERS OR LESS.
 HIT CARRIAGE RETURN IF DATA IS TO COME FROM TERMINAL.
I>


 ENTER CONVERSIONAL MODE FOR DATA INPUT



 INPUT NAME OF FILE DATA IS TO BE WRITTEN TO.
 HIT A CARRIAGE RETURN IF YOU DO NOT WANT THIS FILE.
I>

 INPUT A QUESTION MARK (?) IF MORE INFORMATION IS NEEDED

 INPUT COST DATA (CYD,CCS,CCSH,CI,SDIF):
I>?
 CYD      - COST OF CONCRETE,  $/CUYD (DEFAULT=50.0)
 CCS      - COST OF FLEXURAL STEEL,  $/LB (DEFAULT=0.2)
 CCSH     - COST OF LACING, $/LB (DEFAULT=0.325)
 CI       - INFLATION FACTOR (DEFAULT=1.5)
 SDIF     - DYNAMIC INCREASE FACTOR FOR FLEXURAL STEEL
I>0,0,0,0,1.2

 INPUT HEADING (HDG):
I>?
 HDG      - ALPHANUMERIC HEADING FOR PROBLEM IDENTIFICATION
            68 CHARACTERS MAXIMUM
I>         E X A M P L E   P R O B L E M  1

 INPUT PROGRAM CONTROL (FLAG1,FLAG2,FLAG3FLAG4,FLAG5,PC):
I>?
 FLAG1    - SET = 1 FOR OPTIMIZATION, OTHERWISE = 0
 FLAG2    - SET = 0 TO CALCULATE GAS PRESSURE
            SET = 1 TO INPUT GAS PRESSURE
 FLAG3    - SET = 0 FOR REINFORCING AREA, SQIN/FT
            SET = 1 FOR REINFORCING DIAMETER AND SPACING, IN
 FLAG4    - SET = 1 FOR IMPULSE GRID, OTHERWISE = 0
 FLAG5    - SET = 1 FOR DOOR/WINDOW REACTION PRESENT, OTHERWISE = 0
 PC       - SET = 0 STANDARD PRINTOUT
            SET = 1 PRINT RESPONSE TIME-HISTORY
I>0,0,0,0,0,1

 INPUT LOAD PARAMETERS (WLB,ANUM,RLOD,CASE,APAMB,TAMB,ALTKFT,PERCE):
I>?
 WLB      - WEIGHT OF ACTUAL EXPLOSIVE INCLUDING SAFETY FACTOR, LB
 ANUM     - EXPLOSIVE NUMBER USED TO COMPUTE EXPLOSIVE EQUIVALENCE
 RLOD     - EXPLOSIVE LENGTH TO DIAMETER RATIO (0 FOR SPHERE)
 CASE     - PROJECTILE CASE WEIGHT TO EXPLOSIVE WEIGHT RATIO
 APAMB    - AMBIENT AIR PRESSURE PSIA (DEFAULT=14.69 PSI)
 TAMB     - AMBIENT TEMPERATURE, DEG C (DEFAULT 20 DEG C)
 ALTKFT   - ALTITUDE, 1000 FT (WHEN APAMB AND TAMB NOT SPECIFIED)
 PERCE    - EFFECTIVE IMPULSE FRACTION FOR COMPOSITE
            CONSTRUCTION (DEFAULT=1.0)
I>120,1,0,0,0,0,0,0
```

```
 INPUT GEOMETRY (RR,H,EL,HLIT,ELLIT,AV,AC,ICODE(I), WHERE I=1,2,3,4):
I>?
 RR        - DISTANCE FROM CHARGE TO WALL, FT
 H         - WALL HEIGHT, FT
 EL        - WALL LENGTH, FT
 HLIT      - HEIGHT OF CHARGE, FT
 ELLIT     - DISTANCE OF CHARGE TO LEFT BOUNDARY, FT
 AV        - CELL VOLUME FOR GAS PRESSURE, FT3
 AC        - CELL VENT AREA FOR GAS PRESSURE, FT2
 ICODE(1) - SET = 1 FOR FLOOR REFLECTION, OTHERWISE = 0
 ICODE(2) - SET = 1 FOR ROOF REFLECTION, OTHERWISE = 0
 ICODE(3) - SET = 1 FOR LEFT WALL REFLECTION, OTHERWISE = 0
 ICODE(4) - SET = 1 FOR RIGHT WALL REFLECTION, OTHERWISE = 0
I>6,14,20,7,8,0,0,1,0,1,1

 INPUT STRENGTH PARAMETERS (FC,FST,TC,THETA,SN,TSAND,BL,SL):
I>?
 FC        - CONCRETE DYNAMIC STRENGTH, PSI
 FST       - STEEL STATIC DESIGN STRENGTH, PSI
 TC        - OVERALL THICKNESS OF CONCRETE, IN (12 IN MIN.)
 THETA     - ALLOWABLE ROTATION, DEGREES
 SN        - SUPPORT CODE
             = 1, BOTTOM FIXED
             = 2, BOTTOM AND ONE SIDE FIXED
             = 3, BOTTOM AND TWO SIDES FIXED
             = 4, FOUR SIDES FIXED
             = 5, BEAM SIMPLE SUPPORTS TOP AND BOTTOM
             = 6, BEAM FIXED TOP AND BOTTOM
             = 7, BEAM, SIMPLE SUPPORT TOP, FIXED BOTTOM
 TSAND     - SAND THICKNESS, FT (USUALLY=0)
 BL        - LACING SPACING, IN (TRANSVERSE DIRECTION)
 SL        - LACING SPACING, IN (PEAK TO VALLEY DIRECTION)
I>3750,60000,24,2,3,0,0,0

 INPUT REINFORCEMENT AREA AND DEPTH
 (ASVT,ASVB,ASHT,ASHB,DVT,DVB,DHT,DHB):
 NOTE:  DEPTHS ARE IN INCHES MEASURED FROM THE OUTER CONCRETE
        SURFACE TO THE CENTER OF THE BAR

I>?
 ASVT      - AREA VERTICAL STEEL BLAST SIDE, SQIN/FT
 ASVB      - AREA VERTICAL STEEL OPPOSITE SIDE, SQIN/FT
 ASHT      - AREA HORIZONTAL STEEL BLAST SIDE, SQIN/FT
 ASHB      - AREA HORIZONTAL STEEL OPPOSITE SIDE, SQIN/FT
 DVT       - DEPTH TO VERTICAL STEEL BLAST SIDE
 DVB       - DEPTH TO VERTICAL STEEL OPPOSITE SIDE
 DHT       - DEPTH TO HORIZONTAL STEEL BLAST SIDE
 DHB       - DEPTH TO HORIZONTAL STEEL OPPOSITE SIDE
I>.750,.750,.750,.750,3,3,2,2

 INPUT NAME OF FILE FOR OUTPUT TO BE WRITTEN TO.
 HIT A CARRIAGE RETURN IF OUTPUT TO BE PRINTED AT TERMINAL
I>
```

E X A M P L E   P R O B L E M 1

TNT

EXPLOSIVE PROPERTIES.....CHARGE WEIGHT(LB) = 120.0

NUMBER	EQWT	EFORM KCAL/G	C	H	N	O	AL
1	1.000	-.078400	.370	.022	.185	.423	0.000

PAMB(PSIA)= 14.69 TAMB(C)= 20.00

SHOCK WAVE CALCULATION

INPUT PARAMETERS		CHARGE WEIGHT ADJUSTMENTS	
CHARGE WEIGHT)LB)	= 120.0	ADJUSTED WT(LB TNT)	= 120.0
EXPLOSIVE NUMBER	= 1	HE ENERGY FACTOR	= 1.000
L/D RATIO	= 0.	CHARGE SHAPE FACTOR	= 1.000
CASE/CHARGE WT RATIO	= 0.	CASE WEIGHT FACTOR	= 1.000
CHAMBER PRESSURE(PSIA)	= 14.69	PRESSURE SCALE FACTOR	= 1.000
CHAMBER TEMP(C)	= 20.00	DISTANCE SCALE FACTOR	= .2027
ALTITUDE (KFT)	= 0.	TIME SCALE FACTOR	= .2045
		NORMAL REFL FACTOR	= 7.878

DISTANCE OF CHARGE FROM BLAST WALL	FT.	6.00
CHARGE WEIGHT	LBS.	120.00
BLAST WALL HEIGHT	FT.	14.00
BLAST WALL LENGTH	FT.	20.00
HEIGHT OF CHARGE ABOVE GROUND	FT.	7.00
DIST. BETWEEN CHARGE & LEFT BOUNDARY	FT.	8.00
REFLECTION CODE		1 0 1 1

TOTAL IMPULSE	1038.65 PSI-MS
DURATION OF LOAD	5.90377 MSEC
FICTITIOUS PEAK PRESSURE	351.85852 PSI
EFFECTIVE IMPULSE	1038.65 PSI MS

HEIGHT 168.00 IN LENGTH 240.00 IN

DYNAMIC CONCRETE STRENGTH	3750.00
DYNAMIC STEEL STRESS	72000.00
THICKNESS CONCRETE INCHES	24.0000
THICKNESS OF SAND INCHES	0.0000
THETA ALLOWABLE DEGREES	2.0000

AREA VERT TOP STEEL/FT	.7500	COVER	3.0000
AREA VERT BOT STEEL/FT	.7500	COVER	3.0000
AREA HORIZ TOP STEEL/FT	.7500	COVER	2.0000
AREA HORIZ BOT STEEL/FT	.7500	COVER	2.0000

TYPE 1 CONSTRUCTION

CONCRETE MODULUS PSI	3155923.
RATIO MOD STEEL/CONCRETE	9.19
GROSS MOMENT INERTIA	1152.00
AVE CRACKED MOM INERTIA	198.32
AVE MOMENT INERTIA	675.16
AVERAGE PERCENT STEEL	.0029
D FACTOR MU=1/6	2191685441.
D FACTOR MU= 0.3	2341490753.

ALLOW SHEAR UNREINFORCED WEB	94.64	PSI	2034.71 LBS/IN WIDTH
ALLOW SHEAR AT SUPPORT	594.00	PSI	12771.00 LBS/IN WIDTH

UNREINFORCED CONCRETE THETA LE 2 DEG

POSITIVE VERTICAL MOMENT	91323.53
NEGATIVE VERTICAL MOMENT	91323.53
POSITIVE HORIZONTAL MOMENT	95823.53
NEGATIVE HORIZONTAL MOMENT	95823.53

SUPPORT ON 3 SIDES

YIELD LINE Y ABOVE FLOOR

LOCATION YIELD LINE LENGTH	120.00
LOCATION YIELD LINE HEIGHT	134.75
ULTIMATE LOAD CAPACITY RU	50.2926
SHEAR LOAD AT VERTICAL SUPPORT	4172.52 LB/IN WIDTH
SHEAR LOAD AT HORIZONTAL SUPPORT	4066.26 LB/IN WIDTH
SHEAR AT DISTANCE FROM VERTICAL SUPPORT	157.62 PSI
SHEAR AT DISTANCE FROM HORIZONTAL SUPPORT	153.14 PSI
ALLOWABLE MAX DEFLECTION	4.1975

SHEAR CAPACITY(VC) EXCEEDED

LOAD MASS FACTOR	.6216
MASS CONCRETE ONLY	3351.44

FIRST YIELD POINT AT PT2	
ELASTIC LIMIT RE PSI	20.56
ELASTIC DEFLECTION XE	.0912

SECOND YIELD AT PT 3	
ELASTO PLASTIC LIMIT	25.66
ELASTO-PLASTIC DEFLECTION	.1402
ULTIMATE RESISTANCE	50.29
PLASTIC DEFLECTION	.5075

ULTIMATE RESISTANCE RU	50.29
ELASTIC DEFLECTION LIMIT XE	.3780
STIFFNESS KE	133.06

MASS	3351.436
LOAD	351.859
DURATION	5.904
RESISTANCE	50.293
STIFFNESS	133.059

GAS PRESSURE 0.00 DURATION 0.00

TIME	ACCEL	VEL	DISP	LOAD	RESIS
.126070	.102680	.130903E-01	.165947E-02	344.345	.220807
.378211	.978733E-01	.383779E-01	.973028E-02	329.318	1.30136
.630351	.928232E-01	.624228E-01	.240440E-01	314.290	3.19929
.882491	.875420E-01	.851649E-01	.441260E-01	299.263	5.87137
1.13463	.820434E-01	.106548	.696868E-01	284.236	9.27248
1.38677	.763412E-01	.126518	.100374	269.208	13.3557
1.63891	.704500E-01	.145027	.135821	254.181	18.0723
1.89105	.643848E-01	.162028	.175651	239.154	23.3721
2.14319	.581610E-01	.177480	.219477	224.127	29.2035
2.39533	.517944E-01	.191344	.266899	209.099	35.5134
2.64747	.453012E-01	.203587	.317512	194.072	42.2479
2.89961	.386977E-01	.214178	.370899	179.045	49.3516
3.15175	.339331E-01	.223317	.426668	164.017	50.2926
3.40389	.294493E-01	.231308	.484522	148.990	50.2926
3.65604	.249654E-01	.238168	.544177	133.963	50.2926
3.90818	.204816E-01	.243897	.605348	118.935	50.2926
4.16032	.159978E-01	.248496	.667750	103.908	50.2926
4.41246	.115139E-01	.251965	.731097	88.8808	50.2926
4.66460	.703010E-02	.254303	.795106	73.8535	50.2926
4.91674	.254626E-02	.255510	.859490	58.8262	50.2926
5.16888	-.193758E-02	.255587	.923964	43.7990	50.2926
5.42102	-.642141E-02	.254533	.988244	28.7717	50.2926
5.67316	-.109053E-01	.252348	1.05204	13.7444	50.2926
5.92530	-.150063E-01	.249058	1.11508	0.	50.2926
6.17744	-.150063E-01	.245274	1.17716	0.	50.2926
6.42958	-.150063E-01	.241490	1.23829	0.	50.2926
6.68172	-.150063E-01	.237707	1.29847	0.	50.2926
6.93386	-.150063E-01	.233923	1.35769	0.	50.2926
7.18600	-.150063E-01	.230139	1.41595	0.	50.2926
7.43814	-.150063E-01	.226356	1.47326	0.	50.2926
7.69028	-.150063E-01	.222572	1.52962	0.	50.2926
7.94242	-.150063E-01	.218788	1.58503	0.	50.2926
8.19456	-.150063E-01	.215004	1.63948	0.	50.2926
8.44670	-.150063E-01	.211221	1.69297	0.	50.2926
8.69884	-.150063E-01	.207437	1.74551	0.	50.2926
8.95098	-.150063E-01	.203653	1.79710	0.	50.2926
9.20312	-.150063E-01	.199870	1.84773	0.	50.2926
9.45526	-.150063E-01	.196086	1.89741	0.	50.2926
9.70740	-.150063E-01	.192302	1.94614	0.	50.2926
9.95954	-.150063E-01	.188519	1.99391	0.	50.2926
10.2117	-.150063E-01	.184735	2.04073	0.	50.2926
10.4638	-.150063E-01	.180951	2.08659	0.	50.2926
10.7160	-.150063E-01	.177168	2.13150	0.	50.2926
10.9681	-.150063E-01	.173384	2.17546	0.	50.2926
11.2202	-.150063E-01	.169600	2.21846	0.	50.2926
11.4724	-.150063E-01	.165816	2.26051	0.	50.2926
11.7245	-.150063E-01	.162033	2.30160	0.	50.2926
11.9767	-.150063E-01	.158249	2.34174	0.	50.2926
12.2288	-.150063E-01	.154465	2.38093	0.	50.2926
12.4809	-.150063E-01	.150682	2.41916	0.	50.2926
12.7331	-.150063E-01	.146898	2.45643	0.	50.2926
12.9852	-.150063E-01	.143114	2.49276	0.	50.2926

13.2374	-.150063E-01	.139331	2.52813	0.	50.2926
13.4895	-.150063E-01	.135547	2.56254	0.	50.2926
13.7416	-.150063E-01	.131763	2.59600	0.	50.2926
13.9938	-.150063E-01	.127980	2.62851	0.	50.2926
14.2459	-.150063E-01	.124196	2.66006	0.	50.2926
14.4981	-.150063E-01	.120412	2.69066	0.	50.2926
14.7502	-.150063E-01	.116629	2.72031	0.	50.2926
15.0024	-.150063E-01	.112845	2.74900	0.	50.2926
15.2545	-.150063E-01	.109061	2.77674	0.	50.2926
15.5066	-.150063E-01	.105277	2.80352	0.	50.2926
15.7588	-.150063E-01	.101494	2.82935	0.	50.2926
16.0109	-.150063E-01	.977101E-01	2.85422	0.	50.2926
16.2631	-.150063E-01	.939264E-01	2.87815	0.	50.2926
16.5152	-.150063E-01	.901427E-01	2.90111	0.	50.2926
16.7673	-.150063E-01	.863590E-01	2.92313	0.	50.2926
17.0195	-.150063E-01	.825753E-01	2.94419	0.	50.2926
17.2716	-.150063E-01	.787916E-01	2.96429	0.	50.2926
17.5238	-.150063E-01	.750079E-01	2.98344	0.	50.2926
17.7759	-.150063E-01	.712242E-01	3.00164	0.	50.2926
18.0280	-.150063E-01	.674405E-01	3.01888	0.	50.2926
18.2802	-.150063E-01	.636568E-01	3.03517	0.	50.2926
18.5323	-.150063E-01	.598731E-01	3.05051	0.	50.2926
18.7845	-.150063E-01	.560895E-01	3.06489	0.	50.2926
19.0366	-.150063E-01	.523058E-01	3.07831	0.	50.2926
19.2887	-.150063E-01	.485221E-01	3.09079	0.	50.2926
19.5409	-.150063E-01	.447384E-01	3.10230	0.	50.2926
19.7930	-.150063E-01	.409547E-01	3.11287	0.	50.2926
20.0452	-.150063E-01	.371710E-01	3.12248	0.	50.2926
20.2973	-.150063E-01	.333873E-01	3.13114	0.	50.2926
20.5494	-.150063E-01	.296036E-01	3.13884	0.	50.2926
20.8016	-.150063E-01	.258199E-01	3.14559	0.	50.2926
21.0537	-.150063E-01	.220362E-01	3.15138	0.	50.2926
21.3059	-.150063E-01	.182526E-01	3.15622	0.	50.2926
21.5580	-.150063E-01	.144689E-01	3.16011	0.	50.2926
21.8101	-.150063E-01	.106852E-01	3.16304	0.	50.2926
22.0623	-.150063E-01	.690148E-02	3.16502	0.	50.2926
22.3144	-.150063E-01	.311779E-02	3.16605	0.	50.2926
22.5666	-.150063E-01	-.665899E-03	3.16612	0.	50.2926

NATURAL PERIOD	31.533505
MAXIMUM DEFLECTION	3.166201
TIME TO MAXIMUM DEFLECTION	22.440492
DURATION/NATURAL PERIOD	.187222
LOAD/RESISTANCE	6.996226
ELASTIC DEFLECTION LIMIT	.377971
MAX FRAGMENT SPALL VELOCITY FT/SEC	21.307468

SUBJECT	COMPUTED BY	DATE
EXAMPLE PROBLEM 2	CHECKED BY	DATE

GIVEN : FIGURE SHOWN ON PAGE 35

REQUIRED : ANALYZE LEFT SIDE WALL

PARAMETERS: $R_A = 8'$, $H = 14'$, $L = 16'$, $h = 7'$, $\ell = 10'$

$F_{dc} = 1.25(3000) = 3750$

$F_{dy} = 1.10(60000) = 66000$

BUILD AN INPUT DATA FILE (SEE INPUT DATA FORM)

FILE NAME : BDATA$\overset{B}{2}$A

LINE 1   0, 0, 0, 0, 0

LINE 2   EXAMPLE PROBLEM $\overset{B}{2}$A

" 3   0, 0, 0, 0, 0, 0

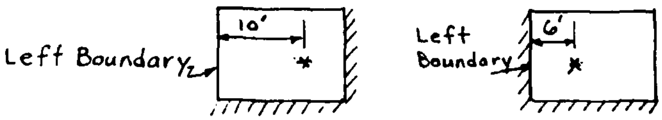
" 4   120 , 1, 0, 0, 0, 0, 0, 0

" 5   8 , 14, 16, 7, $\overset{6}{10}$, 0, 0, 1, 0, $\overset{1}{0}$, $\overset{0}{1}$ } See Explanation Below

" 6   3750, 60000, 24, 2, 2, 0, 0, 0

" 7   .75, .75, .75, .75, 3, 3, 2, 2

<u>Note !</u> This problem will be analysed using two models to show their equivalence, i.e. PROB2A & PROB2B



NSIDE = 2   NSIDE = 2

These are equivalent configurations

File name: BDATA2A

		CYD $/yd^3$	CCS $/lb	CCSH $/lb	CI	SDIF						
		(50.0)	(0.2)	(0.325)	(1.5)	(1.1)	(Default Values)					
	Line 1	0	0	0	0	0						
		HEADING										
	Line 2	EXAMPLE PROBLEM 2A										
		FLAG1	FLAG2	FLAG3	FLAG4	FLAG5	PC					
		Optimize 0 - No 1 - Yes	Input Gas Pressure 0 - Calculate 1 - Input	Reinforcing 0 - AS 1 - D	Impulse Grid 0 - No 1 - Yes	Door Opening 0 - No 1 - Yes	0 - Standard printout 1 - Print response time history					
	Line 3	0	0	0	0	0	0					
		WLB lb	ANUM	RLOD	CASE	APAMB, psia (Default = 14.69)	TAMB, °C (Default = 20)	ALTKFT 10^3 ft	PERCE (Default = 1.0)			
	Line 4	120	1	0	0	0	0	0	0			
		RR ft	H ft	EL ft	HLIT ft	ELLIT ft	AV ft^3	AC ft^2	ICODE			
									F	R	L	R
If FLAG2 = 0,	Line 5A	8	14	16	7	10	0	0	1	0	0	1
		TOTIM psi-msec	H ft	EL ft	FPRES psi	TO msec	PG psi	TG msec	ICODE			
									F	R	L	R
If FLAG2 = 1,	Line 5B											
		FC psi	FST psi	TC in.	THETA degrees	SN	TSAND ft	BL in.	SL in.			
	Line 6	3750	60000	24	2	2	0	0	0			
		ASVT in.^{2}/ft	ASVB in.^{2}/ft	ASHT in.^{2}/ft	ASHB in.^{2}/ft	DVT in.	DVB in.	DHT in.	DHB in.			
If FLAG3 = 0,	Line 7A	0.75	0.75	0.75	0.75	3	3	2	2			
		BAR1	BAR2	BAR3	BAR4	SP1 in.	SP2 in.	SP3 in.	SP4 in.			
If FLAG3 = 1,	Line 7B											
		DVT in.	DVB in.	DHT in.	DHB in.							
If FLAG3 = 1,	Line 7B (Continued)											
		H2 ft	WT ft	B ft	REA lb/in.	RD1 psi	H1 ft					
If FLAG5 = 1,	Line 8											

```
C>OLD,CBARCS
C>CBARCS

 INPUT NAME OF DATA FILE IN 7 CHARACTERS OR LESS.
 HIT CARRIAGE RETURN IF DATA IS TO COME FROM TERMINAL.
I>


 ENTER CONVERSIONAL MODE FOR DATA INPUT



 INPUT NAME OF FILE DATA IS TO BE WRITTEN TO.
 HIT A CARRIAGE RETURN IF YOU DO NOT WANT THIS FILE.
I>

 INPUT A QUESTION MARK (?) IF MORE INFORMATION IS NEEDED

 INPUT COST DATA (CYD,CCS,CCSH,CI,SDIF):
I>0,0,0,0,0

 INPUT HEADING (HDG):
I>          E X A M P L E   P R O B L E M  2A

 INPUT PROGRAM CONTROL (FLAG1,FLAG2,FLAG3FLAG4,FLAG5,PC):
I>0,0,0,0,0,0

 INPUT LOAD PARAMETERS (WLB,ANUM,RLOD,CASE,APAMB,TAMB,ALTKFT,PERCE):
I>120,1,0,0,0,0,0,0

 INPUT GEOMETRY (RR,H,EL,HLIT,ELLIT,AV,AC,ICODE(I), WHERE I=1,2,3,4):
I>8,14,16.,7,10,0,0,1,0,0,1

 INPUT STRENGTH PARAMETERS (FC,FST,TC,THETA,SN,TSAND,BL,SL):
I>3750,60000,24,2,2,0,0,0

 INPUT REINFORCEMENT AREA AND DEPTH
 (ASVT,ASVB,ASHT,ASHB,DVT,DVB,DHT,DHB):
 NOTE:  DEPTHS ARE IN INCHES MEASURED FROM THE OUTER CONCRETE
        SURFACE TO THE CENTER OF THE BAR

I>.75,.75,.75,.75,3,3,2,2

 INPUT NAME OF FILE FOR OUTPUT TO BE WRITTEN TO.
 HIT A CARRIAGE RETURN IF OUTPUT TO BE PRINTED AT TERMINAL
I>BOUT2A

          E X A M P L E   P R O B L E M  2A
 TNT

 EXPLOSIVE PROPERTIES.....CHARGE WEIGHT(LB) =  120.0
 NUMBER EQWT   EFORM EXPLOSIVE COMPOSITION BY WEIGHT
              KCAL/G      C     H     N     O    AL
    1  1.000 -.078400  .370  .022  .185  .423 0.000


 PAMB(PSIA)=  14.69       TAMB(C)=  20.00
```

SHOCK WAVE CALCULATION

INPUT PARAMETERS			CHARGE WEIGHT ADJUSTMENTS		
CHARGE WEIGHT)LB)	=	120.0	ADJUSTED WT(LB TNT)	=	120.0
EXPLOSIVE NUMBER	=	1	HE ENERGY FACTOR	=	1.000
L/D RATIO	=	0.	CHARGE SHAPE FACTOR	=	1.000
CASE/CHARGE WT RATIO	=	0.	CASE WEIGHT FACTOR	=	1.000
CHAMBER PRESSURE(PSIA)	=	14.69	PRESSURE SCALE FACTOR	=	1.000
CHAMBER TEMP(C)	=	20.00	DISTANCE SCALE FACTOR	=	.2027
ALTITUDE (KFT)	=	0.	TIME SCALE FACTOR	=	.2045
			NORMAL REFL FACTOR	=	6.872

DISTANCE OF CHARGE FROM BLAST WALL	FT.	8.00
CHARGE WEIGHT	LBS.	120.00
BLAST WALL HEIGHT	FT.	14.00
BLAST WALL LENGTH	FT.	16.00
HEIGHT OF CHARGE ABOVE GROUND	FT.	7.00
DIST. BETWEEN CHARGE & LEFT BOUNDARY	FT.	10.00
REFLECTION CODE		1 0 0 1

TOTAL IMPULSE	838.95 PSI-MS
DURATION OF LOAD	5.10011 MSEC
FICTITIOUS PEAK PRESSURE	328.99149 PSI
EFFECTIVE IMPULSE	838.95 PSI MS

HEIGHT 168.00 IN LENGTH 192.00 IN

DYNAMIC CONCRETE STRENGTH	3750.00
DYNAMIC STEEL STRESS	66000.00
THICKNESS CONCRETE INCHES	24.0000
THICKNESS OF SAND INCHES	0.0000
THETA ALLOWABLE DEGREES	2.0000

AREA VERT TOP STEEL/FT	.7500	COVER	3.0000
AREA VERT BOT STEEL/FT	.7500	COVER	3.0000
AREA HORIZ TOP STEEL/FT	.7500	COVER	2.0000
AREA HORIZ BOT STEEL/FT	.7500	COVER	2.0000

TYPE 1 CONSTRUCTION

CONCRETE MODULUS PSI	3155923.
RATIO MOD STEEL/CONCRETE	9.19
GROSS MOMENT INERTIA	1152.00
AVE CRACKED MOM INERTIA	198.32
AVE MOMENT INERTIA	675.16
AVERAGE PERCENT STEEL	.0029
D FACTOR MU=1/6	2191685441.
D FACTOR MU= 0.3	2341490753.

ALLOW SHEAR UNREINFORCED WEB	94.64	PSI	2034.71 LBS/IN WIDTH
ALLOW SHEAR AT SUPPORT	594.00	PSI	12771.00 LBS/IN WIDTH

UNREINFORCED CONCRETE THETA LE 2 DEG

POSITIVE VERTICAL MOMENT	83955.88
NEGATIVE VERTICAL MOMENT	83955.88
POSITIVE HORIZONTAL MOMENT	88080.88
NEGATIVE HORIZONTAL MOMENT	88080.88

SUPPORT ON 2 SIDES

YIELD LINE X FROM SIDE

LOCATION YIELD LINE LENGTH	181.34
LOCATION YIELD LINE HEIGHT	168.00
ULTIMATE LOAD CAPACITY RU	26.7847
SHEAR LOAD AT VERTICAL SUPPORT	2914.31 LB/IN WIDTH
SHEAR LOAD AT HORIZONTAL SUPPORT	2818.48 LB/IN WIDTH
SHEAR AT DISTANCE FROM VERTICAL SUPPORT	116.35 PSI
SHEAR AT DISTANCE FROM HORIZONTAL SUPPORT	111.93 PSI
ALLOWABLE MAX DEFLECTION	5.8765

SHEAR CAPACITY(VC) EXCEEDED

LOAD MASS FACTOR	.5858
MASS CONCRETE ONLY	3158.74

FIRST YIELD POINT AT PT2

ELASTIC LIMIT RE PSI	8.93
ELASTIC DEFLECTION XE	.1464
ULTIMATE RESISTANCE	26.78
PLASTIC DEFLECTION	.5803

ULTIMATE RESISTANCE RU	26.78
ELASTIC DEFLECTION LIMIT XE	.5334
STIFFNESS KE	50.21

MASS	3158.738
LOAD	328.991
DURATION	5.100
RESISTANCE	26.785
STIFFNESS	50.215

GAS PRESSURE	0.00	DURATION	0.00

NATURAL PERIOD	49.833446
MAXIMUM DEFLECTION	4.310321
TIME TO MAXIMUM DEFLECTION	33.493264
DURATION/NATURAL PERIOD	.102343
LOAD/RESISTANCE	12.282829
ELASTIC DEFLECTION LIMIT	.533403

MAX FRAGMENT SPALL VELOCITY FT/SEC	20.282837

File name: BDATA2B

	CYD $/yd^3	CCS $/lb	CCSH $/lb	CI	SDIF			
	(50.0)	(0.2)	(0.325)	(1.5)	(1.1)	(Default Values)		
Line 1	0	0	0	0	0			
	HEADING							
Line 2	EXAMPLE PROBLEM 2B							
	FLAG1	FLAG2	FLAG3	FLAG4	FLAG5	FC		
	Optimize 0 - No 1 - Yes	Input Gas Pressure 0 - Calculate 1 - Input	Reinforcing 0 - AS 1 - D	Impulse Grid 0 - No 1 - Yes	Door Opening 0 - No 1 - Yes	0 - Standard printout 1 - Print response time history		
Line 3	0	0	0	0	0	0		
	WLB lb	ANUM	RLOD	CASE	APAMB, psia (Default = 14.69)	TAMB, °C (Default = 20)	ALTKFT 10^3 ft	PERCE (Default = 1.0)
Line 4	120	1	0	0	0	0	0	0
	RR ft	H ft	EL ft	HLIT ft	ELLIT ft	AV ft^3	AC ft^2	ICODE F R L R
If FLAG2 = 0, Line 5A	8	14	16	7	6	0	0	1 0 1 0
	TOTIM psi-msec	H ft	EL ft	FPRES psi	TO msec	PG psi	TG msec	ICODE F R L R
If FLAG2 = 1, Line 5B								
	FC psi	FST psi	TC in.	THETA degrees	SN	TSAND ft	BL in.	SL in.
Line 6	3750	60000	24	2	2	0	0	0
	ASVT $in.^2/ft$	ASVB $in.^2/ft$	ASHT $in.^2/ft$	ASHB $in.^2/ft$	DVT in.	DVB in.	DHT in.	DHB in.
If FLAG3 = 0, Line 7A	0.75	0.75	0.75	0.75	3	3	2	2
	BAR1	BAR2	BAR3	BAR4	SP1 in.	SP2 in.	SP3 in.	SP4 in.
If FLAG3 = 1, Line 7B								
	DVT in.	DVB in.	DHT in.	DHB in.				
If FLAG3 = 1, Line 7B (Continued)								
	H2 ft	WT ft	B ft	REA lb/in.	RD1 psi	H1 ft		
If FLAG5 = 1, Line 8								

```
0080 0 0 0 0 0
0090          E X A M P L E   P R O B L E M   2B
0100 0 0 0 0 0 0
0110 120 1 0 0 0 0 0 0
0120 8 14 16 7 6 0 0 1 0 1 0
0130 3750 60000 24 2 2 0 0 0
0140 0.75 0.75 0.75 0.75 3 3 2 2


         E X A M P L E   P R O B L E M   2B
TNT

EXPLOSIVE PROPERTIES.....CHARGE WEIGHT(LB) =  120.0
NUMBER EQWT   EFORM EXPLOSIVE COMPOSITION BY WEIGHT
             KCAL/G     C     H     N     O    AL
   1  1.000 -.078400  .370  .022  .185  .423 0.000


PAMB(PSIA)=  14.69       TAMB(C)=  20.00

SHOCK WAVE CALCULATION

INPUT PARAMETERS                     CHARGE WEIGHT ADJUSTMENTS
CHARGE WEIGHT)LB)      =   120.0     ADJUSTED WT(LB TNT)  =   120.0
EXPLOSIVE NUMBER       =     1       HE ENERGY FACTOR     =   1.000
L/D RATIO              =  0.         CHARGE SHAPE FACTOR  =   1.000
CASE/CHARGE WT RATIO   =  0.         CASE WEIGHT FACTOR   =   1.000
CHAMBER PRESSURE(PSIA)=   14.69      PRESSURE SCALE FACTOR=   1.000
CHAMBER TEMP(C)        =   20.00     DISTANCE SCALE FACTOR=   .2027
ALTITUDE (KFT)         =  0.         TIME SCALE FACTOR    =   .2045
                                     NORMAL REFL FACTOR   =   6.872


DISTANCE OF CHARGE FROM BLAST WALL        FT.              8.00
CHARGE WEIGHT                            LBS.            120.00
BLAST WALL HEIGHT                         FT.             14.00
BLAST WALL LENGTH                         FT.             16.00
HEIGHT OF CHARGE ABOVE GROUND             FT.              7.00
DIST. BETWEEN CHARGE & LEFT BOUNDARY      FT.              6.00
REFLECTION CODE                                      1  0  1  0

         TOTAL  IMPULSE                  838.95 PSI-MS
         DURATION OF LOAD               5.10011 MSEC
         FICTITIOUS PEAK PRESSURE     328.99149 PSI
         EFFECTIVE IMPULSE               838.95 PSI MS



       HEIGHT     168.00 IN    LENGTH      192.00 IN

    DYNAMIC CONCRETE STRENGTH     3750.00
    DYNAMIC STEEL STRESS         66000.00
    THICKNESS CONCRETE  INCHES     24.0000
    THICKNESS OF SAND   INCHES     0.0000
    THETA ALLOWABLE    DEGREES     2.0000


    AREA VERT TOP STEEL/FT          .7500  COVER    3.0000
    AREA VERT BOT STEEL/FT          .7500  COVER    3.0000
    AREA HORIZ TOP STEEL/FT         .7500  COVER    2.0000
    AREA HORIZ BOT STEEL/FT         .7500  COVER    2.0000
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      TYPE 1 CONSTRUCTION

CONCRETE MODULUS PSI                3155923.
RATIO MOD STEEL/CONCRETE                9.19
GROSS MOMENT INERTIA                 1152.00
AVE CRACKED MOM INERTIA               198.32
AVE MOMENT INERTIA                    675.16
AVERAGE PERCENT STEEL                  .0029
D FACTOR MU=1/6                  2191685441.
D FACTOR  MU= 0.3                2341490753.


ALLOW SHEAR UNREINFORCED WEB     94.64  PSI          2034.71 LBS/IN WIDTH
ALLOW SHEAR AT SUPPORT          594.00  PSI         12771.00 LBS/IN WIDTH
UNREINFORCED CONCRETE  THETA LE 2 DEG

POSITIVE VERTICAL MOMENT      83955.88
NEGATIVE VERTICAL MOMENT      83955.88
POSITIVE HORIZONTAL MOMENT    88080.88
NEGATIVE HORIZONTAL MOMENT    88080.88


SUPPORT ON  2 SIDES

YIELD LINE  X  FROM SIDE

LOCATION YIELD LINE LENGTH                    181.34
LOCATION YIELD LINE HEIGHT                    168.00
ULTIMATE LOAD CAPACITY  RU                   26.7847
SHEAR LOAD AT VERTICAL SUPPORT               2914.31 LB/IN WIDTH
SHEAR LOAD AT HORIZONTAL SUPPORT             2818.48 LB/IN WIDTH
SHEAR AT DISTANCE FROM VERTICAL SUPPORT       116.35 PSI
SHEAR AT DISTANCE FROM HORIZONTAL SUPPORT     111.93 PSI
ALLOWABLE MAX DEFLECTION                      5.8765

     SHEAR CAPACITY(VC) EXCEEDED


LOAD MASS FACTOR              .5858
MASS CONCRETE ONLY          3158.74



FIRST YIELD POINT AT PT2
ELASTIC  LIMIT  RE PSI          8.93
ELASTIC DEFLECTION  XE         .1464
ULTIMATE RESISTANCE            26.78
PLASTIC DEFLECTION             .5803


ULTIMATE RESISTANCE RU         26.78
ELASTIC DEFLECTION LIMIT  XE   .5334
STIFFNESS  KE                  50.21
```

MASS	3158.738
LOAD	328.991
DURATION	5.100
RESISTANCE	26.785
STIFFNESS	50.215

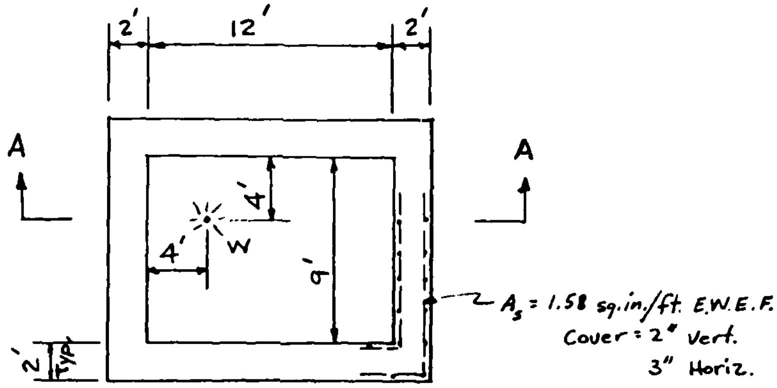
GAS PRESSURE	0.00	DURATION	0.00

NATURAL PERIOD	49.833446
MAXIMUM DEFLECTION	4.310321
TIME TO MAXIMUM DEFLECTION	33.493264
DURATION/NATURAL PERIOD	.102343
LOAD/RESISTANCE	12.282829
ELASTIC DEFLECTION LIMIT	.533403

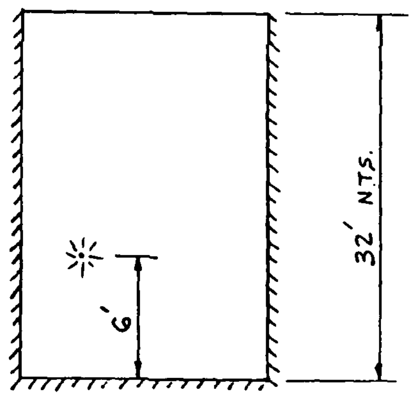
MAX FRAGMENT SPALL VELOCITY FT/SEC	20.282837

SUBJECT	COMPUTED BY:	DATE
EXAMPLE PROBLEM 3	CHECKED BY:	DATE:

PERFORM OPTIMIZATION & USE IMPULSE GRID



PLAN



Lacing
BL = 6"
SL = 6"

SECTION A-A

$\theta = 5°$
FDC = 5000 psi
FS = 40000 psi
FDY = (DIF) × FS = 1.2 × FS
W = 1.2 × 100 = 120 lb. TNT

Cell Vol. = 3456 cu.ft.
Cell Vent Area = 108 sq.ft.

File name: BDATA3

	CYD $/yd^3	CCS $/lb	CCSH $/lb	CI	SDIF			
	(50.0)	(0.2)	(0.325)	(1.5)	(1.1)	(Default Values)		
Line 1	0	0	0	0	1.2			
	HEADING							
Line 2	EXAMPLE PROBLEM 3							
	FLAG1	FLAG2	FLAG3	FLAG4	FLAG5	PC		
	Optimize 0 - No 1 - Yes	Input Gas Pressure 0 - Calculate 1 - Input	Reinforcing 0 - AS 1 - D	Impulse Grid 0 - No 1 - Yes	Door Opening 0 - No 1 - Yes	0 - Standard printout 1 - Print response time history		
Line 3	1	0	0	1	0	1		
	WLB lb	ANUM	RLOD	CASE	APAMB, psia (Default = 14.69)	TAMB, °C (Default = 20)	ALTKFT 10^3 ft	PERCE (Default = 1.0)
Line 4	120	1	0	0	0	0	0	0
	RR ft	H ft	EL ft	HLIT ft	ELLIT ft	AV ft^3	AC ft^2	ICODE F R L R
If FLAG2 = 0, Line 5A	4	32	12	6	4	3456	108	1 0 1 1
	TOTIM psi-msec	H ft	EL ft	FPRES psi	TO msec	PG psi	TG msec	ICODE F R L R
If FLAG2 = 1, Line 5B								
	FC psi	FST psi	TC in.	THETA degrees	SN	TSAND ft	BL in.	SL in.
Line 6	5000	40000	24	5	3	0	6	6
	ASVT in.^{2}/ft	ASVB in.^{2}/ft	ASHT in.^{2}/ft	ASHB in.^{2}/ft	DVT in.	DVB in.	DHT in.	DHB in.
If FLAG3 = 0, Line 7A	1.58	1.58	1.58	1.58	2	2	3	3
	BAR1	BAR2	BAR3	BAR4	SP1 in.	SP2 in.	SP3 in.	SP4 in.
If FLAG3 = 1, Line 7B								
	DVT in.	DVB in.	DHT in.	DHB in.				
If FLAG3 = 1, Line 7B (Continued)								
	H2 ft	WT ft	B ft	REA lb/in.	RD1 psi	H1 ft		
If FLAG5 = 1, Line 8								

```
0010 0 0 0 0 1.2
0020          E X A M P L E   P R O B L E M   3
0030 1 0 0 1 0 1
0040 120 1 0 0 0 0 0 0
0050 4 32 12 6 4 3456 108 1 0 1 1
0060 5000 40000 24 5 3 0 6 6
0070 1.58 1.58 1.58 1.58 2 2 3 3
```

```
         E X A M P L E   P R O B L E M   3
TNT

EXPLOSIVE PROPERTIES.....CHARGE WEIGHT(LB) =  120.0
NUMBER EQWT   EFORM EXPLOSIVE COMPOSITION BY WEIGHT
             KCAL/G     C     H     N     O    AL
   1  1.000 -.078400  .370  .022  .185  .423 0.000


PAMB(PSIA)=  14.69       TAMB(C)=  20.00

SHOCK WAVE CALCULATION

INPUT PARAMETERS                      CHARGE WEIGHT ADJUSTMENTS
CHARGE WEIGHT)LB)      =   120.0      ADJUSTED WT(LB TNT)  =   120.0
EXPLOSIVE NUMBER       =     1        HE ENERGY FACTOR     =   1.000
L/D RATIO              =  0.          CHARGE SHAPE FACTOR  =   1.000
CASE/CHARGE WT RATIO   =  0.          CASE WEIGHT FACTOR   =   1.000
CHAMBER PRESSURE(PSIA)=   14.69       PRESSURE SCALE FACTOR=   1.000
CHAMBER TEMP(C)        =   20.00      DISTANCE SCALE FACTOR=   .2027
ALTITUDE (KFT)         =  0.          TIME SCALE FACTOR    =   .2045
                                      NORMAL REFL FACTOR   =   9.076


DISTANCE OF CHARGE FROM BLAST WALL        FT.             4.00
CHARGE WEIGHT                            LBS.           120.00
BLAST WALL HEIGHT                         FT.            32.00
BLAST WALL LENGTH                         FT.            12.00
HEIGHT OF CHARGE ABOVE GROUND             FT.             6.00
DIST. BETWEEN CHARGE & LEFT BOUNDARY      FT.             4.00
REFLECTION CODE                                      1  0  1  1
```

THE REFLECTED IMPULSE (PSI-MSEC) AT EACH GRID POINT
ON THE BLAST WALL IS...   (MACH REFLECTIONS NOT INCLUDED)

J	I = 1	2	3	4	5
17	450.0	452.8	455.9	463.0	473.5
16	489.4	493.5	497.3	503.2	515.2
15	535.1	543.3	547.7	554.6	552.1
14	584.9	594.5	608.0	601.5	602.7
13	645.9	655.6	655.9	666.6	672.1
12	723.1	733.7	722.3	721.8	753.2
11	828.9	821.7	804.1	799.0	841.8
10	1005.	971.4	919.0	889.2	850.6
9	1245.	1165.	1074.	914.5	920.3
8	1574.	1407.	1040.	986.4	989.7
7	2211.	1726.	1126.	1055.	1054.
6	3190.	1430.	1205.	1111.	1114.
5	2358.	1560.	1274.	1163.	1169.
4	2594.	1663.	1353.	1236.	1241.
3	2561.	1769.	1482.	1372.	1372.
2	3647.	1924.	1707.	1604.	1571.
1	3085.	3549.	3008.	2878.	1928.

J	I = 6	7
17	487.8	486.8
16	523.5	525.4
15	562.6	572.5
14	619.0	632.4
13	687.5	694.2
12	752.3	771.2
11	839.1	882.0
10	964.1	1041.
9	955.6	1265.
8	1054.	1176.
7	1147.	1302.
6	1212.	1694.
5	1266.	1782.
4	1331.	1848.
3	1452.	1930.
2	1612.	2027.
1	2550.	2203.

TOTAL IMPULSE =   1064.40

TOTAL IMPULSE   1158.99 PSI-MS
VENT AREA   108.00   CELL VOLUME   3456.00

GAS PRESSURES CALCULATION
PEAK GAS PRESSURE   143.23
GAS DURATION   13.59
GAS IMPULSE   972.88
TOTAL IMPULSE   1170.74
DURATION OF LOAD   17.12573 MSEC
FICTITIOUS PEAK PRESSURE   135.35086 PSI
EFFECTIVE IMPULSE   1170.74 PSI MS

HEIGHT	384.00 IN	LENGTH	144.00 IN

DYNAMIC CONCRETE STRENGTH	5000.00
DYNAMIC STEEL STRESS	48000.00
THICKNESS CONCRETE INCHES	24.0000
THICKNESS OF SAND INCHES	0.0000
THETA ALLOWABLE DEGREES	5.0000

AREA VERT TOP STEEL/FT	1.5800	COVER	2.0000
AREA VERT BOT STEEL/FT	1.5800	COVER	2.0000
AREA HORIZ TOP STEEL/FT	1.5800	COVER	3.0000
AREA HORIZ BOT STEEL/FT	1.5800	COVER	3.0000

TYPE 3 CONSTRUCTION

CONCRETE MODULUS PSI	3644146.
RATIO MOD STEEL/CONCRETE	7.96
GROSS MOMENT INERTIA	1152.00
AVE CRACKED MOM INERTIA	332.26
AVE MOMENT INERTIA	742.13
AVERAGE PERCENT STEEL	.0061
D FACTOR MU=1/6	2781771691.
D FACTOR MU= 0.3	2971910372.

ALLOW SHEAR UNREINFORCED WEB	115.16	PSI	2475.99 LBS/IN WIDTH
ALLOW SHEAR AT SUPPORT	792.00	PSI	17028.00 LBS/IN WIDTH

UNREINFORCED CONCRETE THETA LE 2 DEG

POSITIVE VERTICAL MOMENT	126400.00
NEGATIVE VERTICAL MOMENT	126400.00
POSITIVE HORIZONTAL MOMENT	113760.00
NEGATIVE HORIZONTAL MOMENT	113760.00

SUPPORT ON 3 SIDES

YIELD LINE Y ABOVE FLOOR

LOCATION YIELD LINE LENGTH	72.00	
LOCATION YIELD LINE HEIGHT	111.37	
ULTIMATE LOAD CAPACITY RU	101.9133	
SHEAR LOAD AT VERTICAL SUPPORT	6592.36	LB/IN WIDTH
SHEAR LOAD AT HORIZONTAL SUPPORT	6809.89	LB/IN WIDTH
SHEAR AT DISTANCE FROM VERTICAL SUPPORT	217.36	PSI
SHEAR AT DISTANCE FROM HORIZONTAL SUPPORT	243.92	PSI
ALLOWABLE MAX DEFLECTION	6.3098	

SHEAR CAPACITY(VC) EXCEEDED

BAR SPACING WIDTH	6.00
BAR SPACING LENGTH	6.00
BAR VERTICAL HEIGHT	18.50
ANGLE ALPHA	80.58
EXCESS SHEAR STRESS	128.76
STEEL STRESS	40000.00
AREA STEEL LACING REQ	.12
BAR NUMBER LACING REQ	4.00

LOAD MASS FACTOR .6985
MASS CONCRETE ONLY 3766.44

FIRST YIELD POINT AT PT2
ELASTIC LIMIT RE PSI 65.66
ELASTIC DEFLECTION XE .0702

SECOND YIELD AT PT 1
ELASTO PLASTIC LIMIT 76.66
ELASTO-PLASTIC DEFLECTION .0943
ULTIMATE RESISTANCE 101.91
PLASTIC DEFLECTION .1497

ULTIMATE RESISTANCE RU 101.91
ELASTIC DEFLECTION LIMIT XE .1234
STIFFNESS KE 825.77

MASS 3766.439
LOAD 135.351
DURATION 17.126
RESISTANCE 101.913
STIFFNESS 825.770

GAS PRESSURE 143.23 DURATION 13.59

TIME	ACCEL	VEL	DISP	LOAD	RESIS
.692956E-01	.377928E-01	.263509E-02	.182600E-03	142.495	.150786
.207887	.372057E-01	.785387E-02	.109092E-02	141.034	.900846
.346478	.364621E-01	.129723E-01	.271321E-02	139.573	2.24048
.485070	.355658E-01	.179648E-01	.503214E-02	138.112	4.15539
.623661	.345207E-01	.228227E-01	.802937E-02	136.651	6.63041
.762252	.333315E-01	.275258E-01	.116841E-01	135.189	9.64839
.900843	.320033E-01	.320544E-01	.159729E-01	133.728	13.1899
1.03943	.305418E-01	.363896E-01	.208694E-01	132.267	17.2334
1.17803	.289533E-01	.405134E-01	.263452E-01	130.806	21.7551
1.31662	.272447E-01	.444087E-01	.323690E-01	129.345	26.7293
1.45521	.254233E-01	.480593E-01	.389075E-01	127.884	32.1286
1.59380	.234967E-01	.514501E-01	.459251E-01	126.423	37.9236
1.73239	.214734E-01	.545671E-01	.533845E-01	124.962	44.0834
1.87098	.193618E-01	.573975E-01	.612463E-01	123.500	50.5754
2.00957	.171710E-01	.599297E-01	.694696E-01	122.039	57.3659
2.14817	.149102E-01	.621533E-01	.780119E-01	120.578	64.4199
2.28676	.125890E-01	.640594E-01	.868295E-01	119.117	71.7012
2.42535	.102174E-01	.656401E-01	.958776E-01	117.656	79.1728
2.56394	.780519E-02	.668893E-01	.105110	116.195	86.7970
2.70253	.536272E-02	.678020E-01	.114481	114.734	94.5353
2.84112	.301591E-02	.683787E-01	.123944	113.273	101.913
2.97971	.262798E-02	.687698E-01	.133462	111.811	101.913
3.11830	.233444E-02	.691135E-01	.143029	110.706	101.913
3.25690	.204362E-02	.694169E-01	.152640	109.610	101.913
3.39549	.175281E-02	.696800E-01	.162289	108.515	101.913
3.53408	.146199E-02	.699028E-01	.171970	107.420	101.913
3.67267	.117118E-02	.700852E-01	.181677	106.324	101.913
3.81126	.880360E-03	.702274E-01	.191406	105.229	101.913
3.94985	.589545E-03	.703293E-01	.201150	104.134	101.913

4.08844	.298730E-03	.703908E-01	.210904	103.038	101.913
4.22703	.791448E-05	.704121E-01	.220663	101.943	101.913
4.36563	-.282901E-03	.703930E-01	.230420	100.848	101.913
4.50422	-.573716E-03	.703337E-01	.240170	99.7524	101.913
4.64281	-.864531E-03	.702340E-01	.249908	98.6571	101.913
4.78140	-.115535E-02	.700940E-01	.259628	97.5617	101.913
4.91999	-.144616E-02	.699137E-01	.269325	96.4664	101.913
5.05858	-.173698E-02	.696932E-01	.278992	95.3711	101.913
5.19717	-.202779E-02	.694323E-01	.288624	94.2757	101.913
5.33576	-.231861E-02	.691311E-01	.298216	93.1804	101.913
5.47436	-.260942E-02	.687896E-01	.307762	92.0850	101.913
5.61295	-.290024E-02	.684078E-01	.317257	90.9897	101.913
5.75154	-.319105E-02	.679857E-01	.326695	89.8944	101.913
5.89013	-.348187E-02	.675233E-01	.336070	88.7990	101.913
6.02872	-.377268E-02	.670206E-01	.345376	87.7037	101.913
6.16731	-.406350E-02	.664776E-01	.354609	86.6084	101.913
6.30590	-.435431E-02	.658943E-01	.363762	85.5130	101.913
6.44450	-.464513E-02	.652706E-01	.372830	84.4177	101.913
6.58309	-.493594E-02	.646067E-01	.381808	83.3223	101.913
6.72168	-.522676E-02	.639025E-01	.390689	82.2270	101.913
6.86027	-.551757E-02	.631580E-01	.399469	81.1317	101.913
6.99886	-.580839E-02	.623731E-01	.408141	80.0363	101.913
7.13745	-.609920E-02	.615480E-01	.416701	78.9410	101.913
7.27604	-.639002E-02	.606825E-01	.425141	77.8457	101.913
7.41463	-.668083E-02	.597768E-01	.433458	76.7503	101.913
7.55323	-.697165E-02	.588307E-01	.441645	75.6550	101.913
7.69182	-.726246E-02	.578443E-01	.449697	74.5596	101.913
7.83041	-.755328E-02	.568177E-01	.457607	73.4643	101.913
7.96900	-.784409E-02	.557507E-01	.465371	72.3690	101.913
8.10759	-.813491E-02	.546434E-01	.472984	71.2736	101.913
8.24618	-.842572E-02	.534959E-01	.480438	70.1783	101.913
8.38477	-.871654E-02	.523080E-01	.487729	69.0830	101.913
8.52336	-.900735E-02	.510798E-01	.494852	67.9876	101.913
8.66196	-.929817E-02	.498113E-01	.501800	66.8923	101.913
8.80055	-.958898E-02	.485025E-01	.508568	65.7969	101.913
8.93914	-.987980E-02	.471534E-01	.515151	64.7016	101.913
9.07773	-.101706E-01	.457640E-01	.521542	63.6063	101.913
9.21632	-.104614E-01	.443343E-01	.527736	62.5109	101.913
9.35491	-.107522E-01	.428643E-01	.533729	61.4156	101.913
9.49350	-.110431E-01	.413539E-01	.539513	60.3203	101.913
9.63210	-.113339E-01	.398033E-01	.545084	59.2249	101.913
9.77069	-.116247E-01	.382124E-01	.550436	58.1296	101.913
9.90928	-.119155E-01	.365811E-01	.555563	57.0342	101.913
10.0479	-.122063E-01	.349096E-01	.560459	55.9389	101.913
10.1865	-.124971E-01	.331978E-01	.565120	54.8436	101.913
10.3251	-.127880E-01	.314456E-01	.569540	53.7482	101.913
10.4636	-.130788E-01	.296532E-01	.573712	52.6529	101.913
10.6022	-.133696E-01	.278204E-01	.577632	51.5576	101.913
10.7408	-.136604E-01	.259474E-01	.581294	50.4622	101.913
10.8794	-.139512E-01	.240340E-01	.584692	49.3669	101.913
11.0180	-.142420E-01	.220803E-01	.587820	48.2715	101.913
11.1566	-.145328E-01	.200864E-01	.590674	47.1762	101.913
11.2952	-.148237E-01	.180621E-01	.593248	46.0809	101.913
11.4338	-.151145E-01	.159976E-01	.595537	44.9855	101.913
11.5724	-.154053E-01	.138928E-01	.597535	43.8902	101.913
11.7110	-.156961E-01	.117477E-01	.599238	42.7949	101.913
11.8496	-.159869E-01	.956230E-02	.600639	41.6995	101.913
11.9881	-.162777E-01	.733658E-02	.601734	40.6042	101.913
12.1267	-.165685E-01	.507055E-02	.602515	39.5088	101.913
12.2653	-.168594E-01	.276421E-02	.602979	38.4135	101.913
12.4039	-.171502E-01	.417577E-03	.603118	37.3182	101.913

```
NATURAL PERIOD                          13.418852
MAXIMUM DEFLECTION                        .603118
TIME TO MAXIMUM DEFLECTION              12.403921
DURATION/NATURAL PERIOD                  1.276244
LOAD/RESISTANCE                          1.405367
ELASTIC DEFLECTION LIMIT                  .123416

MAX FRAGMENT SPALL VELOCITY FT/SEC       5.867672


        TOTAL COST     8253.74
        COUNT             1.00
 X)S ARE
   .240000E+02  .158000E+01  .158000E+01
0 G)S ARE
   .570667E+01  .100000E+04  .860000E+00  .860000E+00  .860000E+00
  .860000E+00  .120000E+02  .176000E+03  .184200E+02
   .184200E+02


 R =  .16425381E+04
 ITER =    0      P =  .16507472E+05     OBJ =  .82537361E+04
 ITER =   12      P =  .12766344E+05     OBJ =  .81489238E+04
0 G)S ARE
   .427794E+01  .100000E+04  .178622E+01  .178622E+01  .198808E+01
  .198808E+01  .301143E+01  .184989E+03  .177634E+02
   .175616E+02
FUNCTION CALLS =   117


 R =  .16425381E+01
 ITER =    0      P =  .81535412E+04     OBJ =  .81489238E+04
 ITER =   39      P =  .55369057E+04     OBJ =  .54700946E+04
0 G)S ARE
   .110635E+00  .100000E+04  .698878E-01  .698878E-01  .795603E+00
  .795603E+00  .253332E+01  .185467E+03  .194941E+02
   .187684E+02
FUNCTION CALLS =   347
XNEXT(I) =
   .145280E+02  .486461E+00  .121806E+01


 R =  .16425381E-02
 ITER =    0      P =  .54432950E+04     OBJ =  .54426446E+04
 ITER =   12      P =  .54153362E+04     OBJ =  .54143391E+04
0 G)S ARE
   .285640E-02  .100000E+04  .787667E-02  .787667E-02  .790261E+00
  .790261E+00  .252616E+01  .185474E+03  .195563E+02
   .187740E+02
FUNCTION CALLS =   193
XNEXT(I) =
   .145261E+02  .443344E+00  .122602E+01
```

```
 R =  .16425381E-05
 ITER =     0     P =  .54140633E+04     OBJ =  .54140545E+04
 ITER =     3     P =  .54140557E+04     OBJ =  .54140358E+04
O G)S ARE
   .847066E-04  .100000E+04  .756447E-02  .756447E-02  .790224E+00
  .790224E+00  .252606E+01  .185474E+03  .195567E+02
   .187740E+02
FUNCTION CALLS =    110
XNEXT(I) =
   .145261E+02  .443337E+00  .122600E+01


 R =  .16425381E-08
 ITER =     0     P =  .54140274E+04     OBJ =  .54140271E+04
 ITER =     3     P =  .54140273E+04     OBJ =  .54140267E+04
O G)S ARE
   .268589E-05  .100000E+04  .755550E-02  .755550E-02  .790223E+00
  .790223E+00  .252605E+01  .185474E+03  .195567E+02
   .187740E+02
FUNCTION CALLS =    140
XNEXT(I) =
   .145261E+02  .443337E+00  .122600E+01
TOTAL FUNCTION CALLS =     907
ITER =,   0     PF =   .5414027E+04     OBJ =   .5414026E+04     X)S ARE
   .145261E+02  .443337E+00  .122600E+01
O G)S ARE
   .921569E-07  .100000E+04  .755522E-02  .755522E-02  .790223E+00
  .790223E+00  .252605E+01  .185474E+03  .195567E+02
   .187740E+02



        HEIGHT     384.00 IN    LENGTH      144.00 IN

     DYNAMIC CONCRETE STRENGTH     5000.00
     DYNAMIC STEEL STRESS         48000.00
     THICKNESS CONCRETE  INCHES    14.5261
     THICKNESS OF SAND   INCHES     0.0000
     THETA ALLOWABLE    DEGREES     5.0000


     AREA VERT TOP STEEL/FT           .4433  COVER    2.0000
     AREA VERT BOT STEEL/FT           .4433  COVER    2.0000
     AREA HORIZ TOP STEEL/FT         1.2260  COVER    3.0000
     AREA HORIZ BOT STEEL/FT         1.2260  COVER    3.0000


     CONCRETE MODULUS PSI               3644146.
     RATIO MOD STEEL/CONCRETE              7.96
     GROSS MOMENT INERTIA                255.42
     AVE CRACKED MOM INERTIA              50.82
     AVE MOMENT INERTIA                  153.12
     AVERAGE PERCENT STEEL                .0059
     D FACTOR MU=1/6                  573953372.
     D FACTOR  MU= 0.3                613184031.
```

```
ALLOW SHEAR UNREINFORCED WEB     114.69  PSI         1379.31 LBS/IN WIDTH
ALLOW SHEAR AT SUPPORT           792.00  PSI         9524.63 LBS/IN WIDTH
UNREINFORCED CONCRETE  THETA LE 2 DEG

POSITIVE VERTICAL MOMENT       18666.35
NEGATIVE VERTICAL MOMENT       18666.35
POSITIVE HORIZONTAL MOMENT     41811.90
NEGATIVE HORIZONTAL MOMENT     41811.90


SUPPORT ON  3 SIDES

YIELD LINE  Y  ABOVE FLOOR

LOCATION YIELD LINE LENGTH                     72.00
LOCATION YIELD LINE HEIGHT                     71.98
ULTIMATE LOAD CAPACITY  RU                   36.0317
SHEAR LOAD AT VERTICAL SUPPORT               2426.97 LB/IN WIDTH
SHEAR LOAD AT HORIZONTAL SUPPORT             1556.05 LB/IN WIDTH
SHEAR AT DISTANCE FROM VERTICAL SUPPORT       168.84 PSI
SHEAR AT DISTANCE FROM HORIZONTAL SUPPORT     103.61 PSI
ALLOWABLE MAX DEFLECTION                      6.3077

     SHEAR CAPACITY(VC) EXCEEDED


    BAR SPACING WIDTH               6.00
    BAR SPACING LENGTH              6.00
    BAR VERTICAL HEIGHT             8.90
    ANGLE ALPHA                    63.78
    EXCESS SHEAR STRESS           114.69
    STEEL  STRESS               40000.00
    AREA STEEL LACING REQ           .09
    BAR NUMBER LACING REQ          3.00


LOAD MASS FACTOR               .7057
MASS CONCRETE ONLY           2303.06



FIRST YIELD POINT AT PT3
ELASTIC  LIMIT  RE PSI           17.77
ELASTIC DEFLECTION  XE           .0920

SECOND YIELD AT PT 2
ELASTO PLASTIC LIMIT             22.02
ELASTO-PLASTIC DEFLECTION        .1372
ULTIMATE RESISTANCE              36.03
PLASTIC DEFLECTION               .2862


ULTIMATE RESISTANCE RU           36.03
ELASTIC DEFLECTION LIMIT  XE     .2371
STIFFNESS  KE                   152.00
```

MASS	2303.061
LOAD	135.351
DURATION	17.126
RESISTANCE	36.032
STIFFNESS	151.995

GAS PRESSURE 143.23 DURATION 13.59

TIME	ACCEL	VEL	DISP	LOAD	RESIS
.191489	.611628E-01	.118102E-01	.227095E-02	141.207	.345173
.574468	.586728E-01	.347711E-01	.134348E-01	137.169	2.04202
.957446	.556220E-01	.566702E-01	.330975E-01	133.132	5.03065
1.34042	.520411E-01	.772986E-01	.607918E-01	129.094	9.24005
1.72340	.479660E-01	.964600E-01	.959740E-01	125.056	14.5876
2.10638	.434373E-01	.113973	.138029	121.019	20.9798
2.48936	.384999E-01	.129672	.186278	116.981	28.3134
2.87234	.333954E-01	.143428	.239985	112.943	36.0317
3.25532	.319537E-01	.155930	.298532	109.623	36.0317
3.63829	.306394E-01	.167916	.361717	106.596	36.0317
4.02127	.293251E-01	.179398	.429347	103.569	36.0317
4.40425	.280109E-01	.190378	.501231	100.542	36.0317
4.78723	.266966E-01	.200853	.577174	97.5156	36.0317
5.17021	.253824E-01	.210826	.656985	94.4888	36.0317
5.55319	.240681E-01	.220295	.740471	91.4620	36.0317
5.93616	.227539E-01	.229261	.827439	88.4352	36.0317
6.31914	.214396E-01	.237724	.917696	85.4084	36.0317
6.70212	.201253E-01	.245683	1.01105	82.3816	36.0317
7.08510	.188111E-01	.253139	1.10731	79.3547	36.0317
7.46808	.174968E-01	.260091	1.20627	76.3279	36.0317
7.85106	.161826E-01	.266541	1.30776	73.3011	36.0317
8.23404	.148683E-01	.272487	1.41157	70.2743	36.0317
8.61701	.135540E-01	.277929	1.51751	67.2475	36.0317
8.99999	.122398E-01	.282868	1.62540	64.2207	36.0317
9.38297	.109255E-01	.287304	1.73503	61.1938	36.0317
9.76595	.961127E-02	.291237	1.84621	58.1670	36.0317
10.1489	.829701E-02	.294666	1.95876	55.1402	36.0317
10.5319	.698275E-02	.297592	2.07248	52.1134	36.0317
10.9149	.566850E-02	.300015	2.18717	49.0866	36.0317
11.2979	.435424E-02	.301934	2.30264	46.0598	36.0317
11.6808	.303998E-02	.303350	2.41871	43.0329	36.0317
12.0638	.172572E-02	.304262	2.53517	40.0061	36.0317
12.4468	.411463E-03	.304672	2.65184	36.9793	36.0317
12.8298	-.902796E-03	.304577	2.76852	33.9525	36.0317
13.2128	-.221705E-02	.303980	2.88502	30.9257	36.0317
13.5957	-.353131E-02	.302879	3.00114	27.8989	36.0317
13.9787	-.484557E-02	.301275	3.11670	24.8720	36.0317
14.3617	-.615983E-02	.299168	3.23150	21.8452	36.0317
14.7447	-.747409E-02	.296557	3.34535	18.8184	36.0317
15.1276	-.878835E-02	.293443	3.45806	15.7916	36.0317
15.5106	-.101026E-01	.289826	3.56942	12.7648	36.0317
15.8936	-.114169E-01	.285705	3.67926	9.73795	36.0317
16.2766	-.127311E-01	.281081	3.78737	6.71113	36.0317
16.6596	-.140454E-01	.275953	3.89357	3.68431	36.0317
17.0425	-.153596E-01	.270323	3.99766	.657495	36.0317
17.4255	-.156451E-01	.264358	4.09948	0.	36.0317
17.8085	-.156451E-01	.258366	4.19901	0.	36.0317
18.1915	-.156451E-01	.252375	4.29623	0.	36.0317
18.5745	-.156451E-01	.246383	4.39117	0.	36.0317
18.9574	-.156451E-01	.240391	4.48381	0.	36.0317
19.3404	-.156451E-01	.234399	4.57415	0.	36.0317

19.7234	-.156451E-01	.228408	4.66220	0.	36.0317
20.1064	-.156451E-01	.222416	4.74795	0.	36.0317
20.4893	-.156451E-01	.216424	4.83141	0.	36.0317
20.8723	-.156451E-01	.210432	4.91258	0.	36.0317
21.2553	-.156451E-01	.204441	4.99145	0.	36.0317
21.6383	-.156451E-01	.198449	5.06802	0.	36.0317
22.0213	-.156451E-01	.192457	5.14230	0.	36.0317
22.4042	-.156451E-01	.186466	5.21429	0.	36.0317
22.7872	-.156451E-01	.180474	5.28398	0.	36.0317
23.1702	-.156451E-01	.174482	5.35138	0.	36.0317
23.5532	-.156451E-01	.168490	5.41648	0.	36.0317
23.9361	-.156451E-01	.162499	5.47929	0.	36.0317
24.3191	-.156451E-01	.156507	5.53980	0.	36.0317
24.7021	-.156451E-01	.150515	5.59802	0.	36.0317
25.0851	-.156451E-01	.144523	5.65394	0.	36.0317
25.4681	-.156451E-01	.138532	5.70757	0.	36.0317
25.8510	-.156451E-01	.132540	5.75890	0.	36.0317
26.2340	-.156451E-01	.126548	5.80794	0.	36.0317
26.6170	-.156451E-01	.120556	5.85468	0.	36.0317
27.0000	-.156451E-01	.114565	5.89913	0.	36.0317
27.3830	-.156451E-01	.108573	5.94129	0.	36.0317
27.7659	-.156451E-01	.102581	5.98115	0.	36.0317
28.1489	-.156451E-01	.965893E-01	6.01871	0.	36.0317
28.5319	-.156451E-01	.905976E-01	6.05398	0.	36.0317
28.9149	-.156451E-01	.846059E-01	6.08696	0.	36.0317
29.2978	-.156451E-01	.786141E-01	6.11764	0.	36.0317
29.6808	-.156451E-01	.726224E-01	6.14603	0.	36.0317
30.0638	-.156451E-01	.666306E-01	6.17212	0.	36.0317
30.4468	-.156451E-01	.606389E-01	6.19592	0.	36.0317
30.8298	-.156451E-01	.546471E-01	6.21742	0.	36.0317
31.2127	-.156451E-01	.486554E-01	6.23663	0.	36.0317
31.5957	-.156451E-01	.426636E-01	6.25354	0.	36.0317
31.9787	-.156451E-01	.366719E-01	6.26816	0.	36.0317
32.3617	-.156451E-01	.306801E-01	6.28048	0.	36.0317
32.7447	-.156451E-01	.246884E-01	6.29051	0.	36.0317
33.1276	-.156451E-01	.186967E-01	6.29824	0.	36.0317
33.5106	-.156451E-01	.127049E-01	6.30368	0.	36.0317
33.8936	-.156451E-01	.671317E-02	6.30683	0.	36.0317
34.2766	-.156451E-01	.721423E-03	6.30768	0.	36.0317

NATURAL PERIOD	24.457807
MAXIMUM DEFLECTION	6.307678
TIME TO MAXIMUM DEFLECTION	34.276566
DURATION/NATURAL PERIOD	.700215
LOAD/RESISTANCE	3.974990
ELASTIC DEFLECTION LIMIT	.237058
MAX FRAGMENT SPALL VELOCITY FT/SEC	25.390621

TOTAL COST	5414.03
COUNT	913.00

SUBJECT	COMPUTED BY	DATE
EXAMPLE PROBLEM 4	CHECKED BY:	DATE:

WALL GEOMETRY SAME AS PROB. 3, EXCEPT WITH ROOF

Cell Volume = 3456 cu.ft.

Cell Vent Area = 16 sq.ft.

NSIDE = 4

Charge Wt. = 120 lb.

$\theta = 12^{\circ}$

File name: BDATA4

	CYD $/yd^3$	CCS $/lb	CCSH $/lb	CI	SDIF			
	(50.0)	(0.2)	(0.325)	(1.5)	(1.1)	(Default Values)		
Line 1	0	0	0	0	1.2			
	HEADING							
Line 2	EXAMPLE PROBLEM 4							
	FLAG1	FLAG2	FLAG3	FLAG4	FLAG5	PC		
	Optimize 0 - No 1 - Yes	Input Gas Pressure 0 - Calculate 1 - Input	Reinforcing 0 - AS 1 - D	Impulse Grid 0 - No 1 - Yes	Door Opening 0 - No 1 - Yes	0 - Standard printout 1 - Print response time history		
Line 3	0	0	0	1	0	0		
	WLB lb	ANUM	RLOD	CASE	APAMB, psia (Default = 14.69)	TAMB, °C (Default = 20)	ALTKFT 10^3 ft	PERCE (Default = 1.0)
Line 4	120	1	0	0	0	0	0	0
	RR ft	H ft	EL ft	HLIT ft	ELLIT ft	AV ft^3	AC ft^2	ICODE F R L R
If FLAG2 = 0, Line 5A	4	32	12	6	4	3456	16	1 1 1 1
	TOTIM psi-msec	H ft	EL ft	FPRES psi	TO msec	PG psi	TG msec	ICODE F R L R
If FLAG2 = 1, Line 5B								
	FC psi	FST psi	TC in.	THETA degrees	SN	TSAND ft	BL in.	SL in.
Line 6	5000	40000	24	12	4	0	6	6
	ASVT $in.^2/ft$	ASVB $in.^2/ft$	ASHT $in.^2/ft$	ASHB $in.^2/ft$	DVT in.	DVB in.	DHT in.	DHB in.
If FLAG3 = 0, Line 7A	1.58	1.58	1.58	1.58	2	2	3	3
	BAR1	BAR2	BAR3	BAR4	SP1 in.	SP2 in.	SP3 in.	SP4 in.
If FLAG3 = 1, Line 7B								
	DVT in.	DVB in.	DHT in.	DHB in.				
If FLAG3 = 1, Line 7B (Continued)								
	H2 ft	WT ft	B ft	REA lb/in.	RD1 psi	H1 ft		
If FLAG5 = 1, Line 8								

```
0010 0 0 0 0 1.2
0020          E X A M P L E   P R O B L E M   4
0030 0 0 0 1 0 0
0040 120 1 0 0 0 0 0 0
0050 4 32 12 6 4 3456 16 1 1 1 1
0060 5000 40000 24 12 4 0 6 6
0070 1.58 1.58 1.58 1.58 2 2 3 3
```

```
        E X A M P L E   P R O B L E M   4
TNT

EXPLOSIVE PROPERTIES.....CHARGE WEIGHT(LB) =  120.0
NUMBER EQWT   EFORM EXPLOSIVE COMPOSITION BY WEIGHT
             KCAL/G      C      H      N      O     AL
   1  1.000 -.078400  .370  .022  .185  .423 0.000
PAMB(PSIA)=  14.69        TAMB(C)=  20.00

SHOCK WAVE CALCULATION

INPUT PARAMETERS                        CHARGE WEIGHT ADJUSTMENTS
CHARGE WEIGHT)LB)      =   120.0        ADJUSTED WT(LB TNT)  =    120.0
EXPLOSIVE NUMBER       =     1          HE ENERGY FACTOR     =    1.000
L/D RATIO              =  0.            CHARGE SHAPE FACTOR  =    1.000
CASE/CHARGE WT RATIO   =  0.            CASE WEIGHT FACTOR   =    1.000
CHAMBER PRESSURE(PSIA)=   14.69         PRESSURE SCALE FACTOR=    1.000
CHAMBER TEMP(C)        =   20.00        DISTANCE SCALE FACTOR=    .2027
ALTITUDE (KFT)         =  0.            TIME SCALE FACTOR    =    .2045
                                        NORMAL REFL FACTOR   =    9.076
DISTANCE OF CHARGE FROM BLAST WALL          FT.              4.00
CHARGE WEIGHT                              LBS.            120.00
BLAST WALL HEIGHT                           FT.             32.00
BLAST WALL LENGTH                           FT.             12.00
HEIGHT OF CHARGE ABOVE GROUND               FT.              6.00
DIST. BETWEEN CHARGE & LEFT BOUNDARY        FT.              4.00
REFLECTION CODE                                       1  1  1  1

THE REFLECTED IMPULSE (PSI-MSEC) AT EACH GRID POINT
 ON THE BLAST WALL IS...   (MACH REFLECTIONS NOT INCLUDED)
```

J	I = 1	2	3	4	5
17	659.9	658.3	659.3	668.5	683.3
16	676.2	676.0	678.0	685.8	702.0
15	707.1	710.7	712.7	721.9	724.1
14	745.1	750.1	761.5	757.1	762.8
13	814.3	819.3	817.5	830.3	840.5
12	880.9	887.1	873.9	875.3	911.1
11	977.2	966.0	946.7	943.3	990.1
10	1146.	1108.	1054.	1026.	991.0
9	1360.	1277.	1185.	1027.	1035.
8	1681.	1512.	1144.	1091.	1097.
7	2312.	1825.	1223.	1154.	1155.
6	3284.	1522.	1296.	1202.	1208.
5	2447.	1646.	1359.	1249.	1257.
4	2677.	1743.	1433.	1317.	1324.
3	2639.	1845.	1557.	1448.	1450.
2	3721.	1995.	1777.	1676.	1645.
1	3155.	3617.	3075.	2946.	1997.

J	I = 6	7
17	701.3	702.3
16	714.4	719.2
15	739.6	753.8
14	784.4	802.0
13	860.6	871.7
12	915.2	938.9
11	992.1	1039.
10	1109.	1190.
9	1074.	1386.

```
8      1165.        1290.
7      1251.        1409.
6      1310.        1795.
5      1357.        1876.
4      1417.        1936.
3      1532.        2013.
2      1688.        2105.
1      2622.        2277.

        TOTAL IMPULSE =     1189.42


        TOTAL  IMPULSE                      1284.01 PSI-MS
VENT AREA     16.00   CELL VOLUME      3456.00

GAS PRESSURES CALCULATION
PEAK GAS PRESSURE            143.23
GAS DURATION                 194.06
GAS IMPULSE                13897.23
TOTAL IMPULSE              13900.05
        DURATION OF LOAD                17.12573 MSEC
        FICTITIOUS PEAK PRESSURE       149.95125 PSI
        EFFECTIVE IMPULSE               13900.05 PSI MS



      HEIGHT     384.00 IN    LENGTH      144.00 IN

    DYNAMIC CONCRETE STRENGTH     5000.00
    DYNAMIC STEEL STRESS         48000.00
    THICKNESS CONCRETE  INCHES    24.0000
    THICKNESS OF SAND   INCHES     0.0000
    THETA ALLOWABLE    DEGREES    12.0000


    AREA VERT TOP STEEL/FT         1.5800  COVER    2.0000
    AREA VERT BOT STEEL/FT         1.5800  COVER    2.0000
    AREA HORIZ TOP STEEL/FT        1.5800  COVER    3.0000
    AREA HORIZ BOT STEEL/FT        1.5800  COVER    3.0000

         TYPE 3 CONSTRUCTION

    CONCRETE MODULUS PSI               3644146.
    RATIO MOD STEEL/CONCRETE              7.96
    GROSS MOMENT INERTIA               1152.00
    AVE CRACKED MOM INERTIA             332.26
    AVE MOMENT INERTIA                  742.13
    AVERAGE PERCENT STEEL                .0061
    D FACTOR MU=1/6                 2781771691.
    D FACTOR  MU= 0.3               297191037[illegible].


    ALLOW SHEAR UNREINFORCED WEB     115.16  PSI          2475.99 LBS/IN WIDTH
    ALLOW SHEAR AT SUPPORT           792.00  PSI         17028.00 LBS/IN WIDTH
    UNREINFORCED CONCRETE  THETA LE 2 DEG

    POSITIVE VERTICAL MOMENT     126400.00
    NEGATIVE VERTICAL MOMENT     126400.00
    POSITIVE HORIZONTAL MOMENT   113760.00
    NEGATIVE HORIZONTAL MOMENT   113760.00


    SUPPORT ON  4 SIDES
```

YIELD LINE Y ABOVE FLOOR

LOCATION YIELD LINE LENGTH	72.00	
LOCATION YIELD LINE HEIGHT	101.36	
ULTIMATE LOAD CAPACITY RU	123.0296	
SHEAR LOAD AT VERTICAL SUPPORT	7148.96	LB/IN WIDTH
SHEAR LOAD AT HORIZONTAL SUPPORT	7482.21	LB/IN WIDTH
SHEAR AT DISTANCE FROM VERTICAL SUPPORT	235.37	PSI
SHEAR AT DISTANCE FROM HORIZONTAL SUPPORT	260.18	PSI
ALLOWABLE MAX DEFLECTION	15.3305	

SHEAR CAPACITY(VC) EXCEEDED

BAR SPACING WIDTH	6.00
BAR SPACING LENGTH	6.00
BAR VERTICAL HEIGHT	18.50
ANGLE ALPHA	80.58
EXCESS SHEAR STRESS	145.02
STEEL STRESS	40000.00
AREA STEEL LACING REQ	.13
BAR NUMBER LACING REQ	4.00

LOAD MASS FACTOR	.6049
MASS CONCRETE ONLY	3261.80

FIRST YIELD POINT AT PT2

ELASTIC LIMIT RE PSI	65.86
ELASTIC DEFLECTION XE	.1882

SECOND YIELD AT PT 3

ELASTO PLASTIC LIMIT	84.54
ELASTO-PLASTIC DEFLECTION	.5401
ULTIMATE RESISTANCE	123.03
PLASTIC DEFLECTION	.6030

ULTIMATE RESISTANCE RU	123.03
ELASTIC DEFLECTION LIMIT XE	.5690
STIFFNESS KE	216.23

MASS	3261.803
LOAD	149.951
DURATION	17.126
RESISTANCE	123.030
STIFFNESS	216.233

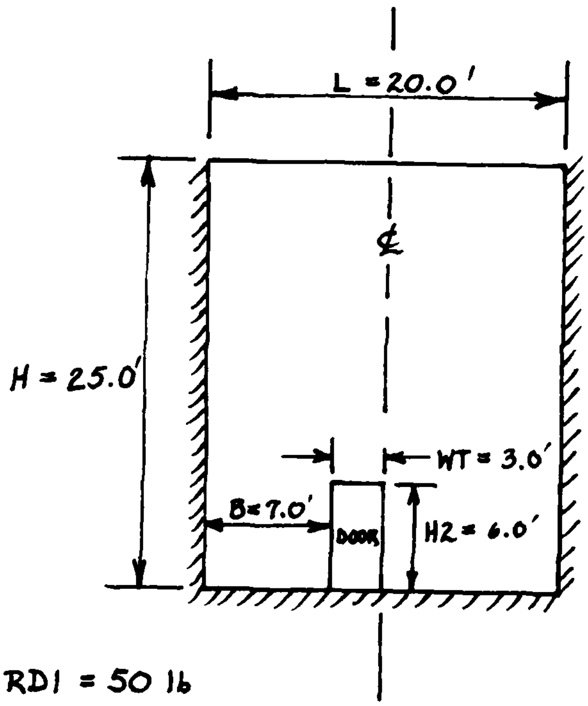
GAS PRESSURE 143.23 DURATION 194.06

NATURAL PERIOD	24.403238
MAXIMUM DEFLECTION	11.032337
TIME TO MAXIMUM DEFLECTION	70.733572
DURATION/NATURAL PERIOD	7.952254
LOAD/RESISTANCE	1.218822
ELASTIC DEFLECTION LIMIT	.568968

MAX FRAGMENT SPALL VELOCITY FT/SEC 17.828073

SUBJECT:	COMPUTED BY:	DATE:
EXAMPLE PROBLEM 5	CHECKED BY:	DATE:

CONDITIONS SAME AS EXAMPLE PROBLEM 1, EXCEPT WALL HEIGHT IS 25 FT AND DOOR IS PRESENT AS SHOWN IN FIGURE BELOW:



RD1 = 50 lb

File name: BDATA5

		CYD $\$/yd^3$	CCS \$/lb	CCSH \$/lb	CI	SDIF			
		(50.0)	(0.2)	(0.325)	(1.5)	(1.1)	(Default Values)		
	Line 1	0	0	0	0	1.2			
		HEADING							
	Line 2	EXAMPLE PROBLEM 5							
		FLAG1	FLAG2	FLAG3	FLAG4	FLAG5	PC		
		Optimize 0 - No 1 - Yes	Input Gas Pressure 0 - Calculate 1 - Input	Reinforcing 0 - AS 1 - D	Impulse Grid 0 - No 1 - Yes	Door Opening 0 - No 1 - Yes	0 - Standard printout 1 - Print response time history		
	Line 3	0	0	0	0	1	0		
		WLB lb	ANUM	RLOD	CASE	APAMB, psia (Default = 14.69)	TAMB, °C (Default = 20)	ALTKPT 10^3 ft	PERCE (Default = 1.0)
	Line 4	120	1	0	0	0	0	0	0
		RR ft	H ft	E[illegible] ft	RLIT ft	ELLIT ft	AV ft^3	AC ft^2	ICODE F R L R
If FLAG2 = 0,	Line 5A	6	25	20	7	8	0	0	1 0 1 1
		TOTIM psi-msec	H ft	EL ft	FPRES psi	TO msec	PG psi	TG msec	ICODE F R L R
If FLAG2 = 1,	Line 5B								
		FC psi	FST psi	TC in.	THETA degrees	SN	TSAND ft	BL in.	SL in.
	Line 6	3750	60000	24	2	3	0	0	0
		ASVT $in.^2/ft$	ASVB $in.^2/ft$	ASHT $in.^2/ft$	ASHB $in.^2/ft$	DVT in.	DVB in.	DHT in.	DHB in.
If FLAG3 = 0,	Line 7A	0.75	0.75	0.75	0.75	3	3	2	2
		BAR1	BAR2	BAR3	BAR4	SP1 in.	SP2 in.	SP3 in.	SP4 in.
If FLAG3 = 1,	Line 7B								
		DVT in.	DVB in.	DHT in.	DHB in.				
If FLAG3 = 1,	Line 7B (Continued)								
		H2 ft	WT ft	B ft	REA lb/in.	RD1 psi	H1 ft		
If FLAG5 = 1,	Line 8	6	3	7	0	50	0		

```
0010 0 0 0 0 1.2
0020          E X A M P L E   P R O B L E M   5
0030 0 0 0 0 1 0
0040 120 1 0 0 0 0 0 0
0050 6 25 20 7 8 0 0 1 0 1 1
0060 3750 60000 24 2 3 0 0 0
0070 0.75 0.75 0.75 0.75 3 3 2 2
0080 6 3 7 0 50 0

         E X A M P L E   P R O B L E M   5
TNT

EXPLOSIVE PROPERTIES.....CHARGE WEIGHT(LB) =  120.0
NUMBER EQWT   EFORM EXPLOSIVE COMPOSITION BY WEIGHT
             KCAL/G     C     H     N     O    AL
   1  1.000 -.078400  .370  .022  .185  .423 0.000


PAMB(PSIA)=  14.69        TAMB(C)=  20.00

SHOCK WAVE CALCULATION

INPUT PARAMETERS                      CHARGE WEIGHT ADJUSTMENTS
CHARGE WEIGHT)LB)      =   120.0      ADJUSTED WT(LB TNT)  =   120.0
EXPLOSIVE NUMBER       =     1        HE ENERGY FACTOR     =   1.000
L/D RATIO              =  0.          CHARGE SHAPE FACTOR  =   1.000
CASE/CHARGE WT RATIO   =  0.          CASE WEIGHT FACTOR   =   1.000
CHAMBER PRESSURE(PSIA)=   14.69       PRESSURE SCALE FACTOR=   1.000
CHAMBER TEMP(C)        =   20.00      DISTANCE SCALE FACTOR=   .2027
ALTITUDE (KFT)         =  0.          TIME SCALE FACTOR    =   .2045
                                      NORMAL REFL FACTOR   =   7.878


DISTANCE OF CHARGE FROM BLAST WALL        FT.                 6.00
CHARGE WEIGHT                            LBS.               120.00
BLAST WALL HEIGHT                         FT.                25.00
BLAST WALL LENGTH                         FT.                20.00
HEIGHT OF CHARGE ABOVE GROUND             FT.                 7.00
DIST. BETWEEN CHARGE & LEFT BOUNDARY      FT.                 8.00
REFLECTION CODE                                          1  0  1  1

         TOTAL  IMPULSE                  896.50 PSI-MS
         DURATION OF LOAD              12.41350 MSEC
         FICTITIOUS PEAK PRESSURE     144.43934 PSI
         EFFECTIVE IMPULSE               896.50 PSI MS



       HEIGHT     300.00 IN    LENGTH      240.00 IN

    DYNAMIC CONCRETE STRENGTH     3750.00
    DYNAMIC STEEL STRESS         72000.00
    THICKNESS CONCRETE  INCHES    24.0000
    THICKNESS OF SAND   INCHES     0.0000
    THETA ALLOWABLE    DEGREES     2.0000


    AREA VERT TOP STEEL/FT          .7500  COVER    3.0000
    AREA VERT BOT STEEL/FT          .7500  COVER    3.0000
    AREA HORIZ TOP STEEL/FT         .7500  COVER    2.0000
    AREA HORIZ BOT STEEL/FT         .7500  COVER    2.0000
```

TYPE 1 CONSTRUCTION

CONCRETE MODULUS PSI	3155923.
RATIO MOD STEEL/CONCRETE	9.19
GROSS MOMENT INERTIA	1152.00
AVE CRACKED MOM INERTIA	198.32
AVE MOMENT INERTIA	675.16
AVERAGE PERCENT STEEL	.0029
D FACTOR MU=1/6	2191685441.
D FACTOR MU= 0.3	2341490753.

ALLOW SHEAR UNREINFORCED WEB	94.64	PSI	2034.71 LBS/IN WIDTH
ALLOW SHEAR AT SUPPORT	594.00	PSI	12771.00 LBS/IN WIDTH

UNREINFORCED CONCRETE THETA LE 2 DEG

POSITIVE VERTICAL MOMENT	91323.53
NEGATIVE VERTICAL MOMENT	91323.53
POSITIVE HORIZONTAL MOMENT	95823.53
NEGATIVE HORIZONTAL MOMENT	95823.53

SUPPORT ON 3 SIDES

DOOR WIDTH	36.00
DOOR HEIGHT	72.00
DISTANCE B FROM LEFT	84.00
DISTANCE A FROM RIGHT	120.00
DOOR REACTION/IN	1273.98
ORIGINAL X YIELD LOCATION	120.00
ORIGINAL Y YIELD LOCATION	157.53

W SECTOR 1	32.95
W SECTOR 2	33.21
W SECTOR 3	33.45
W SECTOR 4	33.20
AVERAGE RU	33.20

X1	132.49
X2	112.62
Y1	72.98
Y2	72.98

******************** C A U T I O N ********************

WALL RESISTANCE SHOULD BE VERIFIED BY INDEPENDENT
CALCULATIONS FOR FINAL DESIGN

YIELD LINE Y ABOVE FLOOR

LOCATION YIELD LINE LENGTH	120.00
LOCATION YIELD LINE HEIGHT	140.62
ULTIMATE LOAD CAPACITY RU	33.2009
SHEAR LOAD AT VERTICAL SUPPORT	3308.85 LB/IN WIDTH
SHEAR LOAD AT HORIZONTAL SUPPORT	2801.30 LB/IN WIDTH
SHEAR AT DISTANCE FROM VERTICAL SUPPORT	127.12 PSI
SHEAR AT DISTANCE FROM HORIZONTAL SUPPORT	106.53 PSI
ALLOWABLE MAX DEFLECTION	4.1975

SHEAR CAPACITY(VC) EXCEEDED

LOAD MASS FACTOR		.6702	
MASS CONCRETE ONLY		3613.56	

FIRST YIELD POINT AT PT2

ELASTIC LIMIT RE PSI		19.13
ELASTIC DEFLECTION XE		.1232

SECOND YIELD AT PT 3

ELASTO PLASTIC LIMIT		24.32
ELASTO-PLASTIC DEFLECTION		.2357
ULTIMATE RESISTANCE		36.80
PLASTIC DEFLECTION		.5408

ULTIMATE RESISTANCE RU		36.80
ELASTIC DEFLECTION LIMIT XE		.3780
STIFFNESS KE		97.36
REDUCED RU FOR DOOR	33.20	36.80

MASS	3613.558
LOAD	144.439
DURATION	12.413
RESISTANCE	33.201
STIFFNESS	97.361

GAS PRESSURE	0.00	DURATION	0.00

NATURAL PERIOD	38.278468
MAXIMUM DEFLECTION	3.024486
TIME TO MAXIMUM DEFLECTION	29.842094
DURATION/NATURAL PERIOD	.324294
LOAD/RESISTANCE	4.350460
ELASTIC DEFLECTION LIMIT	.341009

MAX FRAGMENT SPALL VELOCITY FT/SEC	14.442610

References

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Departments of the Army, Navy, and Air Force. 1969. "Structures to Resist the Effects of Accidental Explosions," TM 5-1300, NAVFAC P-137, AFM 88-22, Washington, D. C.

Ferritto, J. M. 1976. "Development of a Computer Program for the Dynamic Nonlinear Response of Reinforced Concrete Slabs Under Blast Loading," Technical Note 1434, Civil Engineering Laboratory, Port Hueneme, Calif.

Fox, R. L. 1971. Optimization Methods for Engineering Design, Addison Wesley, Reading, Mass.

Gill, J. O., et al. 1973. "Preliminary Report on the Modernization of the Naval Ordnance Production Base and Application of Hazard Risk Analysis Technique," paper presented at the Fifteenth Explosive Safety Seminar, Department of Defense Explosive Safety Board, San Francisco, Calif.

Mendolia, A. 1973. "A New Approach to Explosives Safety," paper presented at the Fifteenth Explosive Safety Seminar, Department of Defense Explosive Safety Board, San Francisco, Calif.

U. S. Army Engineer Division, Huntsville. 1977. "Suppressive Shields, Structural Design and Analysis Handbook," HNDM-1110-1-2, Huntsville, Ala.

Blank form

	CYD $/yd^3$	CCS $/lb	CCSH $/lb	CI	SDIF			
	(50.0)	(0.2)	(0.325)	(1.5)	(1.1)	(Default Values)		
Line 1								
	HEADING							
Line 2								
	FLAG1	FLAG2	FLAG3	FLAG4	FLAG5	PC		
	Optimize 0 - No 1 - Yes	Input Gas Pressure 0 - Calculate 1 - Input	Reinforcing 0 - AS 1 - D	Impulse Grid 0 - No 1 - Yes	Door Opening 0 - No 1 - Yes	0 - Standard printout 1 - Print response time history		
Line 3								
	WLB lb	ANUM	RLOD	CASE	APAMB, psia (Default = 14.69)	TAMB, °C (Default = 20)	ALTKFT 10^3 ft	PERCE (Default = 1.0)
Line 4								
	RR ft	H ft	EL ft	HLIT ft	ELLIT ft	AV ft^3	AC ft^2	ICODE F R L R
If FLAG2 = 0, Line 5A								
	TOTIM psi-msec	H ft	EL ft	FPRES psi	TO msec	PG psi	TG msec	ICODE F R L R
If FLAG2 = 1, Line 5B								
	FC psi	FST psi	TC in.	THETA degrees	SN	TSAND ft	BL in.	SL in.
Line 6								
	ASVT $in.^2/ft$	ASVB $in.^2/ft$	ASHT $in.^2/ft$	ASHB $in.^2/ft$	DVT in.	DVB in.	DHT in.	DHB in.
If FLAG3 = 0, Line 7A								
	BAR1	BAR2	BAR3	BAR4	SP1 in.	SP2 in.	SP3 in.	SP4 in.
If FLAG3 = 1, Line 7B								
	DVT in.	DVB in.	DHT in.	DHB in.				
If FLAG3 = 1, Line 7B (Continued)								
	H2 ft	WT ft	B ft	REA lb/in.	RD1 psi	H1 ft		
If FLAG5 = 1, Line 8								

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Ferritto, John M.
User's guide, computer program for optimum nonlinear dynamic design of reinforced concrete slabs under blast loading (CBARCS) : final report / by John M Ferritto (Civil Engineering Laboratory, Naval Construction Battalion Center), Robert M. Wamsley (U.S. Army Engineer Division, Huntsville), Paul K. Senter (Automatic Data Processing Center, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. ; available from NTIS, [1981].
76, [1] p. : ill. ; 27 cm. -- (Instruction report / U.S. Army Engineer Waterways Experiment Station ; K-81-6)
Cover title.
"March 1981."
"Prepared for Office, Chief of Engineers, U.S. Army."
"This report was prepared under the Computer-Aided Structural Engineering (CASE) Project. A list of published CASE reports is printed on the inside of the back cover."

Ferritto, John M.
User's guide, computer program for optimum : ... 1981.
(Card 2)

Bibliography: p. 75.

1. Blast effect. 2. CBARCS (Computer program). 3. Computer programs. 4. Reinforced concrete. 5. Structural design. I. Wamsley, Robert M. II. Senter, Paul K. III. United States. Army. Corps of Engineers. Office of the Chief of Engineers. IV. U.S. Army Engineer Waterways Experiment Station. Automatic Data Processing Center. V. Title VI. Series: Instruction report (U.S. Army Engineer Waterways Experiment Station) ; K-81-6.
TA7.W34i no.K-81-6

Program Information

Description of Program

CBARCS, called X0056 in the Conversationally Oriented Real-Time Program-Generating System (CORPS) library, is a computer program that may be used to determine the nonlinear dynamic response of reinforced concrete slabs subjected to blast (pressure-time) loading. Given the explosive parameters and geometry of the slab, CBARCS computes the blast environment and the structural resistance, mass, and stiffness of the slab and solves for the dynamic response. The program contains optimization subroutines that provide for automatic optimum design of least-cost structural slabs. CBARCS will assist engineers in the design and analysis of facilities that are intended to contain the effects of accidental explosions.

Coding and Data Format

CBARCS is written in FORTRAN and is operational on the following systems:

a. U. S. Army Engineer Waterways Experiment Station (WES) Honeywell G635.

b. Office of Personnel Management Honeywell 6000 Series at Macon, Ga.

c. Boeing Corporation's CDC CYBER 175.

Data can be input either interactively at execute time or from a prepared data file with line numbers. Output may be directed to an output file or come directly back to the terminal.

How To Use CBARCS

A short description of how to access the program on each of the three systems is provided below. It is assumed that the user knows how to sign on the appropriate system before trying to use CBARCS. In the example initiation of execution commands below, all user responses are underlined, and each should be followed by a carriage return.

WES G635 and Macon systems

After the user has signed on the system, the two system commands FORT and and NEW get the user to the level to execute the program. Next the user issues the run command

RUN WESLIB/CORPS/XØØ56,R

to initiate execution of the program. The program is then run as described in this user's guide. The data file should be prepared prior to issuing the RUN command. An example of initiation of execution is as follows, assuming a data file had previously been prepared:

HIS SERIES 6ØØ ON Ø1/21/81 AT 13.3Ø1 CHANNEL 5647
USER ID - RØKACASEMP
PASSWORD - [redacted]
SYSTEM? FORT NEW
READY
*RUN WESLIB/CORPS/XØØ56,R

Boeing system

The log-on procedure is followed by a call to the *CORPS* procedure file

OLD,CORPS/UN=CECELB

to acces the CORPS library. The file name of the program is used in the command

CALL,CORPS,XØØ56

to initiate execution of the program. An example is:

WELCOME TO THE BCS NETWORK
YOUR ACCESS PORT IS SWY 55
SELECT D RED SERVICE: EKS1
81/Ø1/21. 13.3Ø.Ø1.
EKS1 175G.NØ46Ø.68BA 8Ø/Ø9/14.DS-Ø Ø2.39.Ø5. 8Ø/Ø9/16.
USER ID: CERØC1
PASSWORD -
[redacted]
TERMINAL: 124,TTY
RECOVER/USER ID: CASE

(Continued)

*

C>OLD,CORPS/UN=CECELB

C>CALL,CORPS,XØØ56

How To Use CORPS

The CORPS system contains many other useful programs which may be catalogued from CORPS by use of the LIST command. The execute command for CORPS on the WES and Macon systems is:

```
RUN WESLIB/CORPS/CORPS,R
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

on the Boeing computer, the commands are:

```
OLD,CORPS/UN=CECELB
ENTER COMMAND (HELP,LIST,BRIEF,MESSAGE,EXECUTE, OR STOP)
*?LIST
```

WATERWAYS EXPERIMENT STATION REPORTS PUBLISHED UNDER THE COMPUTER-AIDED STRUCTURAL ENGINEERING (CASE) PROJECT

	Title	Date
Technical Report K-78-1	List of Computer Programs for Computer-Aided Structural Engineering	Feb 1978
Instruction Report O-79-2	User's Guide: Computer Program with Interactive Graphics for Analysis of Plane Frame Structures (CFRAME)	Mar 1979
Technical Report K-80-1	Survey of Bridge-Oriented Design Software	Jan 1980
Technical Report K-80-2	Evaluation of Computer Programs for the Design/Analysis of Highway and Railway Bridges	Jan 1980
Instruction Report K-80-1	User's Guide: Computer Program for Design/Review of Curvilinear Conduits/Culverts (CURCON)	Feb 1980
Instruction Report K-80-3	A Three-Dimensional Finite Element Data Edit Program	Mar 1980
Instruction Report K-80-4	A Three-Dimensional Stability Analysis/Design Program (3DSAD)	
	Report 1: General Geometry Module	Jun 1980
Instruction Report K-80-6	Basic User's Guide: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Dec 1980
Instruction Report K-80-7	User's Reference Manual: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Dec 1980
Technical Report K-80-4	Documentation of Finite Element Analyses	
	Report 1: Longview Outlet Works Conduit	Dec 1980
	Report 2: Anchored Wall Monolith, Bay Springs Lock	Dec 1980
Technical Report K-80-5	Basic Pile Group Behavior	Dec 1980
Instruction Report K-81-2	User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods (CSHTWAL)	
	Report 1: Computational Processes	Feb 1981
	Report 2: Interactive Graphics Options	Mar 1981
Instruction Report K-81-3	Validation Report: Computer Program for Design and Analysis of Inverted-T Retaining Walls and Floodwalls (TWDA)	Feb 1981
Instruction Report K-81-4	User's Guide: Computer Program for Design and Analysis of Cast-in-Place Tunnel Linings (NEWTUN)	Mar 1981
Instruction Report K-81-6	User's Guide: Computer Program for Optimum Nonlinear Dynamic Design of Reinforced Concrete Slabs Under Blast Loading (CBARCS)	Mar 1981
Instruction Report K-81-7	User's Guide: Computer Program for Design or Investigation of Orthogonal Culverts (CORTCUL)	Mar 1981

DATE

ILME